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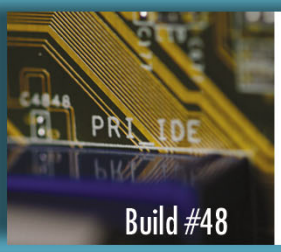

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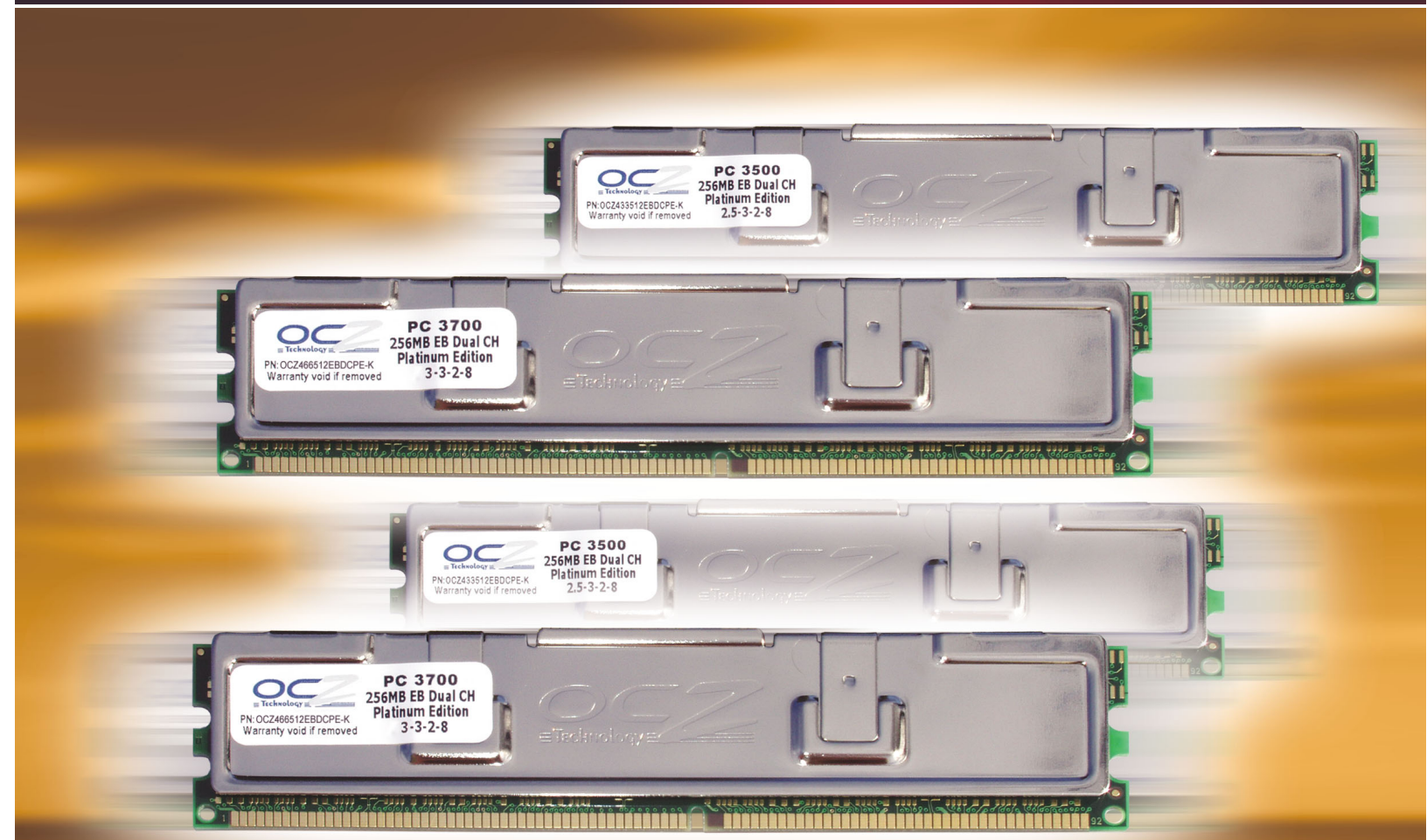

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PC Builder

Vol. 8, Issue 5

Reference Series

In this issue we set out to build systems for 52 specific user scenarios. We researched and bought parts, struggled to stay within budgets, pieced together components, and figured out workarounds for the inevitable system conflicts. We built systems for consumers and also small businesses. And sometimes—as in the case of our Monster PC—we built systems just for fun. When we were finished, we scored the difficulty of each build on a five-point scale (with five being most difficult). We also indicated how much we spent for parts, less shipping and taxes. Learn from our triumphs as well as our failures, and use these articles as guidelines for your own system builds.

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So You Want To Build Your Own PC

We Cover The Basics Of PC Construction

Editor's Note:
This article is for people who are building their first computer systems or who want a refresher course on some building basics. If you're an experienced system builder, you can skip this introductory article and go right to the systems of your choice. Have fun building your new rigs.

There are several reasons you might decide to take the leap into building your own machine. Maybe you're budget-minded and simply want to save a few bucks by building your own box. Or perhaps you're a hands-on kind of person who really likes the feeling of building things from scratch, getting into the inner workings of your rig. Or maybe you just like the satisfaction of knowing that anything that could possibly go wrong with your system can be traced back to an individual you are intimately familiar with: yourself. You want to know every inch of the machine you use, and if something fizzles out, you want to be able to isolate and repair/replace it in a short amount of time with minimal fuss. Whatever your reason, the fact that you are reading this issue means that you are ready to blaze new trails and take the plunge into the exciting world of building your own PC.

Throughout this issue we discuss the topic of system building in great detail. We cover both standalone computers and networks, and we talk about traditional PCs, as well as other digital electronic systems. In each article, we first determine our needs and goals for the system so we know what parts we need to buy. Often we work with a specific budget, and we go through the same give-and-take process that any user does who is trying to get the most machine for his or her money. In most cases we actually purchase our components (occasionally, we substitute equivalent parts that we already had on hand, but we point out what the original parts would have cost had you purchased them at retail). When we have gathered all our parts, we prep our work environment, making sure that we have all the necessary tools and equipment for the job. We then build and test our system and provide some personal observations about its performance.

This particular article provides some basic information that applies to any building project. Read the articles in the rest of this issue for detailed buying, building, and testing information on more than 50 specific types of systems.

Now, let's get started. . . .

Determine Needs & Goals

Before we can even shop for parts to build a machine, we need to determine what it is we want to do with our computer. Usually, we have

some sort of task in mind when we set out to buy a rig. If you're a gamer who wants to tailor your system toward getting the best graphics and frames per second for your money, you will have different needs than someone who's looking to build a digital entertainment center or a video-editing or graphic design workstation. Knowing what you intend to do with the machine after you build it is critical to ensure that you select the best parts and end up with a system that you'll be happy with.

Once we've determined what type of system we're going to build, we can then compile a list of the items we will need to build it. In general, though, all computing systems will need at least the following:

Case
Power supply
Processor (with heatsink and fan)
Motherboard
RAM
Hard drive
Video controller
Audio controller
CD, DVD, and/or floppy drive
Mouse
Keyboard
Monitor
Modem and/or network card (depending on if you use a dial-up or high-speed connection)

However, like just about everything in life, there are dozens of choices to make for each component that goes into your system: the wattage of the power supply, the type of processor you want (AMD or Intel) and the speed you need, the amount of memory on the video card. There are many choices you can make. The goal of the system you are building and the size of your budget will determine all of these factors.

For instance, a rig built for gaming will probably have a fairly fast processor, plenty of RAM (512MB to 1GB) that runs at a higher bus speed (PC 3200 or higher), a video card with a more powerful graphics processor and more video RAM (128MB to 256MB), and perhaps an audio controller. Gamers might also spring for surround-sound speakers and a larger monitor, as well as a large hard drive so they can install their entire game library (or as much of it as they can fit on the drive).

In contrast, a digital entertainment center would need to focus heavily on storage space, audio out, and video out. It wouldn't need the fastest processor available but would likely require a very high-quality sound card for digital surround sound (5.1 or 6.1 is preferred) for going out to your tuner and a TV-tuner card for TiVo-style television recording.

Just remember that whatever type of system you intend to build will determine the type of components you need to purchase. If all you want to do is hop on the 'Net, send email, and type up a few documents for school or work, an entry-level processor, 128MB to 256MB of RAM, and a motherboard with onboard video and audio will be all that you need.

Research Technologies

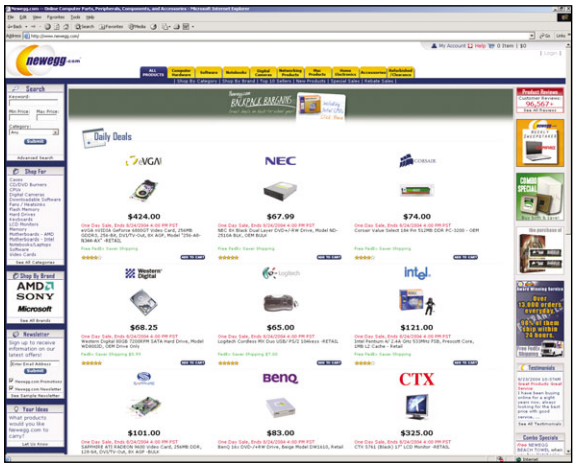
AMD or Intel? DDR SDRAM or RAMBUS RDRAM? Onboard RAID or individual ATA . . . or SCSI? There's a lot of technology to research when you decide to build a machine, and at first, it's quite daunting. However, the fact that you have a solid game plan for the goal of your machine puts you miles ahead in terms of deciding what you will need technology-wise.

Processors come in two major brands: AMD and Intel. The advantage of one or the other literally changes daily, based on a complex algorithm based on the phases of the moon and the lyrics of a Britney Spears song (which is silly because, really, they're all the same). The major thing to pay attention to when choosing either Intel or AMD is the fact that the motherboard you pick will depend on the processor you pick, as AMD chips do not work on Intel boards and vice-versa. Also, the type of memory you purchase will depend heavily on your processor selection; you cannot use RAMBUS memory on AMD systems, but you can use SDRAM or DDR SDRAM on either Intel or AMD.

In each of the system builds in this issue, we will discuss what parts we are purchasing and why. You may choose different components for your own system based on your own particular needs or budget, but our articles will serve as guidelines for whatever components are necessary for each type of system configuration.

Procure Components

After you have determined what parts you need, it's time to go get it all—and that can sometimes be quite a task. There are two ways you can shop for parts. The first is at your good old local brick-and-mortar PC supply store; the other is online. Each shopping method has its distinct advantages and disadvantages, and determining which is best for you is really dependant on two factors: your comfort level with a type of retailer and the amount of time you are willing to wait for your components to be in hand.



Newegg.com has pretty much everything you'll need to put together your own machine, provided you choose to shop online rather than in a good old-fashioned brick-and-mortar store.

If you are the impatient sort, if you like to actually see what you are purchasing, or if you feel more comfortable working with a local retailer, shopping around town at the PC stores will be your best bet. The downsides are that you often will pay more for components, you have a smaller selection of products to choose from per store, and you will be paying state sales tax (unless you live in Alaska, Delaware, Montana, New Hampshire, or Oregon, you lucky

person, you). The upside, however, is that you have the components you need today instead of waiting the seven to 10 days it takes for online delivery (unless you pay the upgrade fees for second-day or overnight shipping), and you can talk to a human being about the products you're buying.

Some folks, however, prefer shopping online, either due to the great prices they find or perhaps because there are no PC parts stores anywhere near them. While it is true that finding a reliable retailer online that sells the products you need for a fair price used to be difficult, thanks to advancements in ecommerce and price publishing, it's now relatively easy. Web sites such as www.shopper.com and www.pricewatch.com make finding the lowest price on components and comparing prices among vendors a piece of cake (upside-down, even). All you have to do is hop on a site, search for the type of component you want (for example, an AMD Athlon XP 3200+ processor), and voila! Every vendor in their list that carries that item will appear on the page. You can even sort by lowest price or vendor ranking.

On a budget? Check out sites such as pricewatch.com to ensure the lowest price on your hardware.

There are several caveats we need to mention. Some e-tailers post ridiculously low prices on one item, only to jack up the price on others that you need to complete your machine (for instance, they may highlight an insanely low price on a processor but overprice the motherboard and memory to compensate). Some sites also draw users in with low product prices only to surprise them with inflated shipping fees. Pricewatch and Shopper both take measures to expose hidden shipping fees by showing the total price on products shipped to your door, but if you are contemplating buying from a vendor you're not familiar with, watch out for abnormal shipping charges. When it comes to buying products online, we recommend sticking with the larger, more established vendors such as Egghead (www.egghead.com) and Buy.com. You may occasionally find lower prices at a "no-name" site, but with better-known vendors, you have a greater chance of avoiding unpleasant surprises with your orders.

A few things to keep in mind: First, have the items you order shipped to a safe location, be it a work address or a friend/relative you know will be home to accept delivery (and note that if you accept mail at a P.O. Box, most carriers cannot deliver there). Never let the shipper leave the item at the door. Not only do things like heat, humidity, static-charged air, and cold have very negative effects on electronic components, but so do dogs, wild raccoons, and sticky-fingered strangers.

Next, be sure to collect all of your receipts from your purchases (print out each and every receipt you are presented with when you purchase an item online) and keep them in a safe place. These will be important should you need to return an item. Most online retailers keep a record of your purchase on their servers, but it is possible in this day of worms and viruses that an online transaction record could be lost. In that case, having a paper copy of the receipt is well worth the time it took to print it out.

It's also a good idea to purchase your items on a regular credit card as opposed to an ATM/Debit card because most credit card companies offer at least a basic measure of protection in the form of chargebacks should a problem arise.

Build Your System

So now you've either been to the store and picked up all your parts or you are waiting for Mr. Postman to trot your box o' stuff to your door. Either way, it's time to go ahead and set up your work environment. You will need:

A well-lit workspace—This is the single most important tool you need to successfully build a system right the first time. The surface should be as large as is practical, such as a clean kitchen table or a clear workbench. Make sure that the only items in your work area are your tools and the components for the one system that you are building right now. And for Pete's sake, do NOT drink anything while building your PC. Condensation from the glass on your fingers while you mess around with electrical components . . . yeah. Not very bright.

Small Phillips head screwdriver

Regular-size Phillips head screwdriver

Blade screwdriver

Pliers

Screw retriever—Optional. This is a spring-loaded tool with a plunger on one end that, when depressed, extends gripping "teeth" from the other end. Don't use a magnet-based one; that's just asking for trouble.

Static strap—Optional, but highly recommended. If you cannot locate one, just hold the side of the metal case to keep yourself grounded.

Zip ties—Optional, but they keep the cords out of the fans.

Thermal paste—Optional but highly recommended because it helps transfer the heat from your processor to the heatsink.

For customized cases (with lights, Plexiglas windows, customized fan grills, and whatnot), you may need a Dremel tool and a jigsaw, but case modifications are easily an article (and even an entire magazine, such as our own *PC Modder*) unto themselves, and we won't discuss them here.

Once your environment is set, it's time to get to work. Putting the machine together can be one heck of a scary prospect when it's your first time handling all of these components. Fortunately, as time has passed, manufacturers have made the actual putting together of a system extremely easy. Each slot on a motherboard is form-factored to fit one way and only one way. Memory, video cards, PCI cards (audio, network card/modem, etc.), processor: They all have very distinctive connection

patterns, and they only attach one way. The users manual for the motherboard you purchased should have a guide for setup and installation of most of the pieces of hardware you have; you should read the entire manual for your motherboard (and probably your processor, as well) before you begin installing your components. Instructions for connecting the power supply, processor, and hard drive do vary from manufacturer to manufacturer. Because the motherboard is literally the foundation of your machine, becoming intimately familiar with every single jumper, switch, and slot is just a good idea.

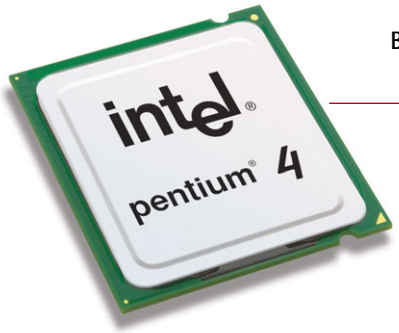
The placement of parts inside the machine is fairly straightforward; for almost every single piece you need to install, you can simply look at the type and shape of the connector and determine easily where it belongs. There are a few simple guidelines to follow, such as placing a spare fan at the front of the case with the airflow marker pointing inward to draw cool air from outside into the box. Also, it's a really good idea to place your hard drive in the bottom-most bay on your system and continue to stack new drives upward from the bottom. This places them close to the fresh, cool air that's being drawn into the system and reduces the chance of a heat-related catastrophe.

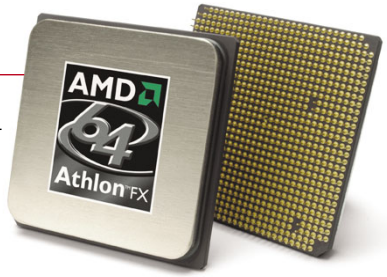
Another tip: Leave an empty bay between hard drives when you install more than one and an empty PCI slot between the video card and the first PCI card. This allows more air to flow through those channels, keeping your expensive heat-generating components cool. We also recommend you use a good thermal compound when connecting the heatsink to the processor. The heatsink that ships with your processor will have a tiny square of transfer material where it connects to the processor, but most times it's insufficient for proper heat transfer. A thermal compound (silver-based compounds, while more expensive, are the best and well worth the extra money) will definitely aid in the transfer of heat from the processor to the heatsink. Before you take this step, however, please refer to the documentation that comes with your processor in regards to what will or will not void a warranty in regard to cooling systems.

Screwdrivers are probably the most essential tools in PC assembly; you don't have to splurge and get insulated screwdrivers like these Wiha models, but it can't hurt.

Once you have your parts installed, your controller cables connected to your hard drive and CD-ROM, and your power supply plugged in to the motherboard, it's time to turn the system on and make sure all is well. You may want to properly secure the door of your computer case before you even plug the machine in, much less turn it on. More than once we have foregone this step and turned on the machine while monkeying around inside the box and fried RAM, hard drives, processors; you name it, we've probably cooked it simply because we weren't careful. The likelihood that you will damage your machine simply by running it with the case lid off is extremely slim, so the choice is yours. We merely recommend caution when your internals are exposed.

Check your monitor once the machine is on. If you see a RAM countdown, you know you've passed the first test, as the video card, RAM, and processor are all connected and working fine. The next bit is to make sure the system knows what speed processor you are running and that it can see the hard and optical drives attached.





Building your own system is all about choice. Do you want to run your system on the newest Pentium 4, or would you rather put an Athlon 64 at the heart of your beast?

That information should pop up immediately after the RAM check. If it does not, refer to your motherboard's manual on instructions for entering the BIOS and telling the system to find the drives. Next, you will install your operating system of choice, a topic that has entire books devoted to it and is far too great to cover in any detail in this article. Refer to the in-struction manual for your operating system for details on this aspect of setting up the system. One thing that we will suggest: Once you get your network card or modem up and running, check the Internet immediately for any driver or operating system updates for your machine.

Final Remarks

Building your own PC need not be scary or daunting. As you have seen here, the part that seems the most frightening to most people is actually the easiest part of the whole ordeal. If you devote some time to determining the goals for your system and researching the technologies you plan on choosing, organize a reliable, well-lit workspace, and read your motherboard's manual, you will hurdle the most difficult parts of the process with ease.

Whether your reward comes from a few extra dollars left in your wallet or from the satisfaction of knowing that you created a monster using only your bare hands, you will gain a satisfaction from using your hand-built machine that you never experienced with a store-bought box. RS

by Joe Peacock

Best AMD-based PC For Under $500

Use Rebate Savvy To Save A Bundle On A Budget System

Build #1 Skill Level: 1 **2** 3 4 5 ***Apprentice***

We love a challenge. Some people try to climb Mount Everest or set new land speed records; we're out to overclock and set new benchmark records. This time, we're going to see how far $500 will stretch to build the best budget AMD rig.

Goal

Armed with $500 and a little resourcefulness, we wanted to create an AMD-based system without scouring eBay for a 3-year-old clunker. We sought out newer components to construct a system that wouldn't cost us an arm and a leg but could also easily handle MS Office applications and Web browsing and possibly run games with decent quality. We also tried to make our AMD PC attractive to power users without scaring away newbies.

Background

We began our quest knowing the best system would combine performance and value. An Athlon 64 FX-53 and 2GB of RAM was out of the question, but we thought we could find an Athlon XP and enough memory to give our PC a little bite without taking a big bite out of our wallet.

Bargain Hunting 101

While we decided to use Windows XP as our OS, you can't ignore Linux's reasonable price of . . . well, free. Keeping in mind we're trying to put together a PC for inexperienced users/builders as well as power users, we thought a familiar OS that would let users add applications without causing much trouble would be the best route. We found an OEM copy of WinXP from AGSolutions for $64, so keep in mind you'll have extra cash for a better CPU, more memory, or a better graphics card if you opt to use Linux. It's a great choice for an experienced Linux user or someone who wants to build a Linux system with minimal investment.

Our OS options may have been limited, but we had a little more freedom searching for the right CPU. We found our darling in the 2.0GHz Athlon XP 2400+ with an included heatsink and fan. We paid $72 at Newegg, but you can save $5 to $15 if you're willing to sacrifice a little clock speed. Likewise, you can find a faster processor if you want to cut costs in another category.

We needed a mobo that wouldn't cost a fortune but would also give us expansion options for potential upgrades. Shuttle happily obliged us with its AN-35N Ultra. We liked the AN-35N because it came with a lot of options for a starter board and only cost us $54.99. Supporting FSB speeds of up to 400MHz and three DIMM slots that accept up to 3GB RAM, the AN-35N left plenty of room for upgrading. This particular board did lack SATA controllers and wouldn't work with Athlon 64 processors.

System Notes	
Physical Description	
Height	17 inches; 44cm
Width	7.4 inches; 19cm
Depth	19.5 inches; 50cm
Form Factor	ATX
System Specs	
Motherboard: nForce 2 ULTRA 400 + MCP FSB @ 400/333/266/200MHz; Supports Socket A Athlon XP/Athlon/Duron processors, two USB 2.0 ports, three DDR DIMM Slots, Integrated 6.1 Audio, Integrated 10/100 LAN	
CPU: AMD 2.0GHz Athlon XP 2400+, 266MHz FSB	
Memory: 256MB PC3200 DDR SDRAM	
Hard Drive: 40GB 7,200rpm	
Video Card: 64MB Radeon 7000	
Software Highlights: Windows XP Home SP1	
Performance	
3DMark01	1953
3DMark03	N/A
PCMark04	2670
Summary Remarks	
Building this system came down to hunting for the right mail-in rebates. The lack of a 3DMark03 score is puzzling, but our Budget AMD handily beat our Budget Intel in PCMark04. Makes a great gift for someone who needs a basic computer. This is also a good system for anyone who wants to learn the basics of PC building without spending next month's mortgage payment.	

If we stumbled at any point during the planning phases of our AMD-based rig, it would be when we selected a graphics card. Our initial plan of attack was to find an AGP card with 64MB RAM for under $50. We thought we had struck gold when we found a Sapphire 64MB Radeon 7000 card for $36.50 from Newegg.com; in reality, we had unearthed a graphics fossil. Our Graphicsaurus Rex didn't reveal its limitations until we swapped it with an ATI 128MB Radeon 9200 during the testing phase.

With a nonintegrated video card, we decided to buy a smaller amount of memory and pay a little extra for quality. PC2100 memory might have saved us a few bucks, but we thought paying a small premium for PC3200 would be more beneficial in the long run. 256MB of Corsair memory at $51 from Newegg did the trick, but we would have taken 512MB in a heartbeat if we had an extra $40 to spare. This would have been a good route if we had chosen a mobo with integrated graphics.

We found a 40GB hard drive from Maxtor to satisfy our storage needs. The 7,200rpm DiamondMax Plus D740X was $48 from Compuplus.com.

Mail-In Savings

If we took any chances during the process, it was in selecting a case and peripherals. For $19.99 (after a $40 mail-in rebate), we bought a Soyo case, 350W power supply, keyboard, optical mouse, and speaker combo from Tigerdirect.com. This was a big gamble, primarily because inexpensive power supplies regularly burn out. We fully expected the speakers to produce less than robust sound; testing revealed that our assumption was accurate.

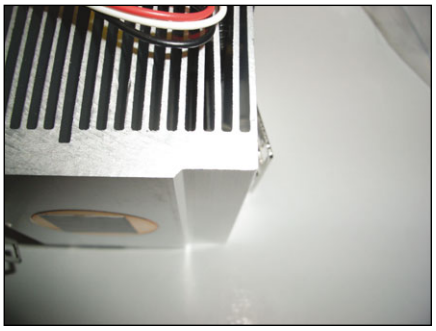
We almost hunted for an optical drive without considering DVD burners, and it's a good thing we didn't. We scored a very nice BenQ DVD+RW burner from Tigerdirect.com for $39.97 after a $20 mail-in rebate—sweet.

After we wrapped up our package with a 17-inch refurbished Dell CRT monitor from Tigerdirect.com ($59.97 after mail-in rebate) and a HEISEI external 8-in-1 card reader/writer ($13), our total expenditures came to $459.42.

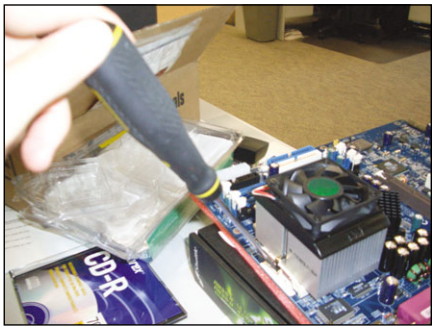
The Build

Even though we were using a lot of the same parts components from our budget Intel build (see page 12), we encountered a few differences when we put together our AMD system. Overall, we hit a few more snags but were able to iron out most of the problems.

Before starting, we cleared a large enough area to spread out our parts. We also suggest working in an environment free of static electricity. Picking an uncarpeted floor and using an antistatic wrist strap (available for under $10 in most home electronic stores) should do the trick. Keep in mind that static electricity can quickly fry your components. We placed a hard plastic floor mat over our carpeted floor and touched the case's metal chassis to discharge any lingering static electricity.



There's only one position you can use to attach the heatsink and fan, and this groove makes the process easier.



A flathead screwdriver delivers the pressure you'll need to attach the heatsink's clip to the socket, but be careful you don't slip.

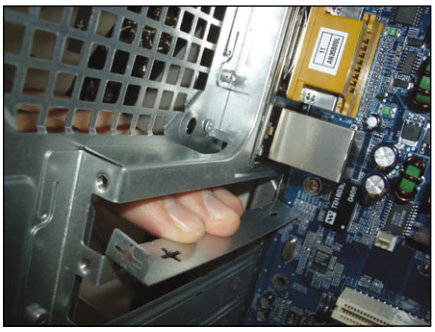
We highly recommend installing the CPU and heatsink/fan combo on the mobo *before* you mount the mobo on the case's chassis. Doing this gives you a more expansive workspace than a case's small (and sometimes physically awkward) interior. First, we located the socket on the motherboard. The socket is approximately a 2- x 2-inch plastic square with many small holes and a small plastic or metal lever located on one of its sides. We lifted the lever on the socket and aligned the CPU with the socket using an arrow on the pin side of the CPU. If the CPU doesn't fit into the socket without any applied pressure, double check that it's properly aligned. Once the CPU was in the socket, we locked it in place by closing the lever (here, you'll want to carefully exert a little pressure).

Attaching the heatsink/fan combo was by far the most difficult task we faced during the physical build. We removed the plastic cover from the bottom of the heatsink (in some cases, this is a thin strip of plastic tape). We lined up the metal clamp with the three plastic hooks on either end of the socket and latched it onto the hooks on one side. Next we used a flathead screwdriver (see photo) to apply a generous amount of pressure to hook the clamp to the other plastic hooks. Exercise extreme caution during this step; one slip of the screwdriver will almost surely damage your motherboard.

We also installed our memory module before attaching our mobo to the chassis, but it's not much more difficult to do if you've already attached the mobo. Like the CPU, you can only install memory modules one way. Look for the notch on your memory module and line it up with the DIMM slot (usually located to the right of the CPU socket if you orient your mobo so that the CPU socket is near the top). We pushed down on one DIMM slot's ejector clips and pushed the memory module in place. The ejector clips automatically locked into place when we pushed it in far enough.

With our CPU and memory module in place, we attached the mobo to the chassis. We opened up our case and used the case's included screws to fasten the mobo to the brass standoffs. Don't remove the standoffs and fasten the mobo directly to the chassis; your mobo will short out and possibly sustain permanent damage.

Installing the graphics card, hard drive, and DVD burner were routine steps. New builders will notice that the AGP slot for the graphics card is slightly offset from the other (PCI) slots below the CPU socket. Typically, there is a small clip similar to the DIMM slot ejector clips you must use to lock the graphics card in place. Mount the DVD burner in any open 5.25-inch bay and the hard drive in an internal 3.5-inch bay, but try to use bays that will keep the IDE cables from becoming an obstruction or heat concern.



Punch out these back panels when you know which AGP or PCI slots you need to use.

Both drives connected to the mobo with IDE cables. Remember to connect your optical drive's audio cable to its corresponding headers on the mobo.

If you find that the two IDE cables are causing too much chaos in your case, two quick tricks will help. For starters, you can use round IDE cables, which are thinner, more flexible, and less bulky. They generally cost about $10. You can also use one IDE cable to connect both your hard drive and optical drive to the mobo. To do this, reposition the jumper on one of these drives to the slave setting. Usually, there is a diagram on the drive itself. Attach the connector at the end of the IDE cable to the Master drive and the connector in the middle of the IDE cable to the Slave drive. You can combine these two solutions to save even more space.

We carefully examined our mobo's users manual before connecting any wires or cables to their corresponding headers or connectors. Because our case included two front USB ports, we attached those wires to their proper headers. You may encounter a similar situation if your case has an internal card reader or FireWire port. You can avoid a lot of frustration (and restocking fees) by finding a mobo that will support any extra ports or drives that may be included on your case. Keep in mind that the layout of every motherboard will be different.

A Little BIOS Work

When we powered on our budget AMD system for the first time, it didn't go quite as smoothly as when we powered our budget Intel PC. Our mobo recognized the CPU as an AMD Athlon XP 1800+ instead of the XP 2400+ we had installed. It also listed our memory speed at 200MHz instead of 400MHz. We never saw a POST (Power On Self Test) screen, either.

Changing a few settings in the BIOS seemed to do the trick. We pressed the DELETE key to enter the BIOS menu. We entered Advanced BIOS Features and changed First Boot to CDROM. This booted the WinXP install disc when we restarted. Next we entered Advanced Chipset Features and made changes to the FSB Frequency and Memory Frequency. We changed the FSB Frequency to 133MHz (Double Data Rate technology will double the FSB to the CPU's stock 266MHz) and the Memory Frequency to Auto. Because we didn't install any floppy drives, we entered Standard CMOS Features and changed Drive A to None. We pressed F10 to save our changes and exit out of the BIOS menu.

This time, our system rewarded our work by properly identifying our CPU and memory. We received a POST screen and pressed ENTER to begin the WinXP installation (any key will work). It was a routine installation; even if this is your first build, the software requires very little information from you. However, if you ordered an OEM copy, the product key you need to proceed through the installation may be on the cellophane wrapping. *Don't* throw it away.

Software Setbacks

After installing WinXP, we installed our hardware drivers and included software. Although we didn't encounter any difficulties with our drivers, the Nero Express CD we received with the BenQ DVD+RW drive was particularly pesky.

To install our mobo's drivers, we inserted the CD in our DVD+RW drive

Parts List

Component	Model	Price	Notes
Case	SOYO Dragon	$19.99	After $40 mail-in rebate
Power Supply	350W Maxpower PSU	$0	Included with case
Motherboard	Shuttle AN35N Ultra	$54.99	
Processor	AMD Athlon XP 2400+	$72	
Memory	256MB Corsair Value Select RAM	$51	
Hard Drive	Maxtor DiamondMax Plus 7,200rpm	$48	OEM
Video Card	Sapphire 64MB RADEON 7000	$36.50	
Sound Card	Integrated Into Motherboard	$0	
Network Card	Integrated Into Motherboard	$0	
CD Drive	See DVD+RW Drive	$0	
DVD-ROM/ CD-RW Drive	See DVD+RW Drive	$0	
DVD+RW Drive	BenQ 12x/4x/4x DVD+RW Drive	$39.97	OEM; After $40 mail-in rebate
Monitor	Dell 17-inch CRT monitor	$59.97	Refurbished; After $20 mail-in rebate
Speakers	SOYO Dragon	$0	Included with case
Keyboard	SOYO Dragon	$0	Included with case
Mouse	SOYO Dragon	$0	Included with case
Removable Storage Drive	HEISEI 8-in-1 External Card Reader/Writer	$13	
OS	Windows XP Home	$64	On sale. Clearing out SP1 before SP2 release.
Total		**$459.42**	

and clicked Install Mainboard AN35 Series Driver and Install NVIDIA Chipset Driver. We took the same steps to install our graphics card driver and 8-in-1 card reader/writer driver as we did with the budget Intel system (see page 12). Because WinXP comes with keyboard and mouse drivers, we didn't need to install those.

The BenQ DVD+RW writer included two CDs: the previously-mentioned Nero Express and Intervideo's WinDVD suite of applications. We had no problems with the Intervideo CD, but Nero Express was a bit of a nightmare. We inserted the Nero Express CD and clicked Install Nero Express and InCD. When it took around two minutes to change to the next menu, we started to worry. When we clicked install Nero Express, our system froze. Although we installed InCD, it rewarded us with a Blue Screen of Death after we restarted. We restarted WinXP in Safe Mode and uninstalled InCD. We didn't experience any problems after this.

While our DVD-writing software was a flop, it was the only bump in the road we encountered. If you run into similar problems during your budget build, you can use WinXP to burn CDs, and a plethora of DVD data writing software exists. WinDVD Creator, which is included on Intermedia's CD, will create and burn DVD movies.

We had no problems using WinXP to burn a CD. We inserted a blank CD-RW into the drive and then clicked Start and My Computer. We double-clicked the DVD burner icon and dragged the window to a corner. Next, we selected the files we wanted to write and dragged them into the first window. Once we were ready to write to the CD, we clicked Write These Files To CD in the left column of the first window.

Testing

Once we installed our drivers and software, we took our thoroughbred (no intentional pun on our CPU's Thoroughbred core) to the track and put it through its paces. We ran two benchmarks on our budget rig, 3DMark03 and PCMark04. Because we know numbers only tell half of the story, we also performed a variety of computing tasks to get a qualitative feel for our PC. We surfed the 'Net, played Halo, and watched "The Matrix." All in the name of research, of course.

A Graphic Difference In Graphics

We had a spare 128MB ATI Radeon 9200 graphics card lying around so we decided to perform a little experiment in budget PC performance. The ATI card retails for as low as $69 from some online stores, and we were curious how much difference a little more than $30 would make. In 3DMark03, the Sapphire card could'nt even post a score, so we ran 3DMark01 instead. The Sapphire card scored 1953 while the ATI card returned a 7001 score.

Before you dismiss the Sapphire card, our system scored 2670 and 3170 in PCMark04 with the Sapphire and ATI cards, respectively. Our 3DMark03 and PCMark04 scores revealed two interesting bits of information. First, it was obvious that our Sapphire card was far too ancient for today's games. However, the much closer PCMark04 scores indicate you probably won't see any other significant performance gains with a better video card.

Also, don't equate a better graphics card with tasks such as scanning photos or editing photos with a program such as Adobe Photoshop; more RAM and a faster processor are better buys for these jobs.

As a reference point, our analog-to-digital media converter system scored 2482 in 3DMark03 and 3618 in PCMark0. (Don't be alarmed; this system cost roughly three times more than our budget AMD.)

Our budget AMD computer handled almost everything we threw at it. Halo was virtually unplayable with the Sapphire card, but the ATI performed admirably (we gladly spent plenty of time confirming this). The lobby shootout scene from "The Matrix" looked great on our computer and didn't skip at any point during the action. We also didn't have any problems with any MS Office applications.

Final Remarks

Considering that our system cost less than $500, we were pleased with our results. Sure, it probably won't satisfy a power user thirsty for top-notch performance, but it's still a fantastic PC. Building a budget PC is great for anyone who wants to try his hand at PC building without a large investment. Experienced builders may enjoy assembling a computer that makes an excellent gift for the casual PC user. Either way, we think you'll be impressed with what you can put together with $500. RS

by Vince Cogley

Bling Bling

After we had our rig alive and kicking, we had a little loot left to give our system the "My budget PC is cooler than yours" look. Because sale prices and rebates vary, everyone will have a different accessories budget. (And frankly, we don't blame you if you want to use every last cent buying the best essential hardware.) Here's a short list of sub-$20 accessories to give your computer its own style:

C.H.I.M.P. (monitor mirror): Think of it as a rear-view mirror for your PC. C.H.I.M.P. is about the size of a closed fist and perches on your monitor. A quick glance will reveal any approaching boss, giving you plenty of time to ALT-TAB out of FarCry and get back to those TPS reports.

$9.99 at www.thinkgeek.com

USB Massage Ball: We know an all-night LAN party can leave you a little tense. It uses a USB port and is the closest thing to Swedish massage you'll get without leaving your computer.

$9.99 at www.cyberguys.com

Domino's Pizza: OK, so it's not exactly a computer accessory, but we were hungry after the build. This Italian classic comes in several sizes and your choice of toppings.

Prices vary according to local specials and coupons.

Best Intel-Based PC For Under $500

You Can Still Build A Great Computer Without Spending An Arm And A Leg

Build #2 Skill Level: 1 **2** 3 4 5 ***Apprentice***

$505 will buy you this computer and an iced latte from Starbucks.

Let's face it: Nothing's cheap these days. Gas prices are making it cost-prohibitive to drive anything with four wheels and an internal combustion engine, and Mountain Dew is more affordable than milk.

Unfortunately, this phenomenon is also beginning to affect PC building. With so many PC manufacturers offering dirt-cheap systems these days, budget PC builders are becoming a rare breed. That didn't stop us from using a little cash and some innovation to cook up an Intel-based PC. Skip the sex appeal; we're after "cents appeal."

Goal

With $500 in our pockets, we set out to build the best Intel-based PC for our money. This system won't break any benchmarks, but it won't break the bank, either. If you want to surprise Mom and Dad with a new PC without resorting to ramen noodles as the sole item on your grocery list, we'll show you how.

Background

Forget playing Half Life 2 on a flat-panel display with the latest ATI or NVIDIA graphics card; we knew we'd have to sacrifice a lot of goodies to build our Intel rig for 500 clams. Still, we thought we wanted a system that could handle the latest OS, perform basic word processing and Web browsing, and possibly burn DVDs.

If you're building a PC on a tight budget, you'll probably have just enough capital for the essentials and possibly a bell and/or whistle. You'll need an OS, CPU (along with a fan and heatsink), at least 256MB of RAM if you want to run Windows XP, a hard drive, an optical drive such as a CD-ROM or DVD-ROM, monitor, keyboard, mouse, and motherboard. Graphics, sound, and LAN cards are almost essential, but they are also integrated on many motherboards.

Filling The Digital Shopping Cart

Picking an OS was both one of the easiest and hardest chores. On one hand, WinXP is a good choice if you plan on building a PC for someone who isn't a power user. Unfortunately, even the OEM version costs around $65, which is a decent chunk of our resources. You can't beat Linux's price tag, but inexperienced users may want to stick with an OS they feel comfortable with. Since we wanted to build a system that anyone could use, we grudgingly ponied up $64 for the OEM version of WinXP from AGsolutionsPC.com and looked to cut costs elsewhere. If you opt for Linux, you should have extra cash left for more memory or a better video card.

We started searching for a Pentium 4 CPU but decided to hunt for a solid Celeron when we couldn't find a new P4 much below $100. Plus, we didn't want a processor that would go to waste just because we couldn't afford other powerful components. Ultimately, we went with a 2.4GHz Celeron that included a heatsink and fan for $72.

When shopping for a motherboard, we wanted to avoid mobos that had onboard video. The price difference between mobos with onboard video and those

System Notes	
Physical Description	
Height	17 inches; 44cm
Width	7.4 inches; 19cm
Depth	19.5 inches; 50cm
Form Factor	ATX
System Specs	
Motherboard: SiS 655FX/SiS 964L FSB at 800/533/400MHz; Supports Intel Pentium 4 (Prescott, Northwood, Williamette)/Celeron processors, 6 USB 2.0 ports, 4 DDR DIMM Slots, Integrated 5.1 Audio, Integrated 10/100 LAN	
CPU: Intel 2.4GHz Celeron, 400MHz FSB	
Memory: 256MB PC3200 DDR SDRAM	
Hard Drive: 40GB 7,200rpm	
Video Card: 64MB Radeon 7000	
Software Highlights: Windows XP Home SP1	
Performance	
3DMark03	60
PCMark04	2276
Summary Remarks	
Moderate performance on a budget. Don't let the benchmark scores fool you, this is still a great PC for everyday tasks. Runs IE and MS Office apps with ease. This is a great system for first-time builders who want minimal financial investment and low risk. Depending on mail-in rebates, consider purchasing a better graphics card or low-end Pentium 4 CPU.	

without was negligible, and we thought one stick of memory and an inexpensive graphics card would be better than better than buying extra memory to support the onboard video. ASROCK's P4S55FX motherboard was a steal for $48. The board fit our needs perfectly and offered a lot of options available for upgrading down the road.

Extra memory and onboard video would probably satisfy most budget builders, but we wanted our budget rig to handle some of today's games, too. Finding a card that could handle Doom 3 or Half Life 2 would probably be a stretch, but we thought we could find something to run newer games at a decent frame rate. The 64MB Sapphire Radeon 7000 seemed up to the task, and we thought it was a steal at $36.50. It was only later that we found a 128MB ATI Radeon 9200 card from Spartan Technologies for $69. Testing revealed that buying the Sapphire card was one of our biggest blunders.

If you're not constructing your system for graphics-intensive applications, skipping the graphics card for a mobo with onboard video and using the extra money for more memory might be a better option. In our case, the separate graphics card alleviated the need to purchase extra memory, so we thought 256MB would be just about right. There wasn't a tremendous price gap between PC2100 and PC3200 RAM, so we searched for good PC3200 memory, thinking that we wouldn't need to upgrade it if we purchased a faster CPU down the road. We found 256MB of Corsair Value Select PC3200 at Newegg.com for $51.

During our hunt for an ATX case, we stumbled across a deal we couldn't pass up. Tigerdirect.com offered a SOYO case with a 350W power supply, keyboard, optical mouse, and speakers for $19.99 after a $40 mail-in rebate. Buying these together saved us time and money. After finding a refurbished Dell monitor at Tigerdirect.com for $59.97 (after a $20 mail-in rebate), we had a case, power supply, and peripherals for well under $100.

Initially, we thought a 20GB, 7,200rpm hard drive would save us some precious cash and still deliver reasonable performance and capacity; we discovered that 40GB hard drives weren't much more expensive, so we scooped up a Maxtor DiamondMax Plus D740X for $48 at www.compuplus.com.

Six rear USB ports provided us with ample expansion options.

A couple of round IDE cables will help clear up this clutter. A little bit, anyway.

Call us greedy, but we wanted a DVD in our rig. Tigerdirect.com hooked us up with a BenQ DVD+RW burner for an astounding $39.97 after mail-in rebates. Although we won't win any beauty contests with a white DVD burner in a silver and black case, you have to admit that you won't find too many sub-$500 systems with a DVD burner, either.

Instead of buying a 3.5 floppy diskette drive, we picked out an external 8-in-1 card reader/writer from HEISEI for $13. Combined with our burner, we ended up with an impressive array of media compatibility on our budget system.

After mail-in rebates, our grand total came to $452.43. Although this doesn't include shipping charges and taxes, we were pretty impressed with our accomplishment. We hoped our power supply or mobo wouldn't fizzle out because buying budget power supplies or mobos can be a gamble. When the last piece arrived, we were ready to start the party.

The Build

Three letters characterized most of the products we received: OEM. Our memory, DVD burner, graphics card, and hard drive all arrived in OEM packaging. The only minor faux pas we noticed was that the Sapphire graphics card's users manual (included on CD-ROM) was for the Radeon 9000, not the Radeon 7000.

Before we even opened the case, we attached the CPU, heatsink, fan, and memory module to our motherboard. This is optional, but some prefer doing this before affixing the motherboard to the case; we like installing these components when the mobo is lying on a spacious flat surface instead of vertically oriented in a cramped computer case.

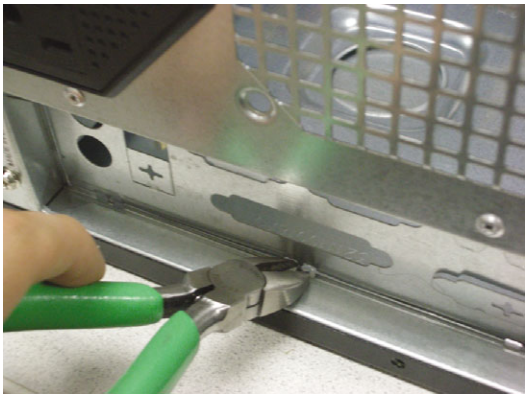
Always eliminate the potential for static electricity before you remove the mobo from its antistatic bag. If possible, avoid building your system in a room with carpeted floors; tile floors work great. We didn't use an antistatic wrist strap, but it's not a bad idea to pick one up. We used a hard plastic floormat and discharged any static electricity we may have accumulated by touching our case's chassis.

To install the CPU, we opened the lever on the mobo's processor socket and lined up the Celeron's pins to match the socket. (There's only one way for the CPU to fit into the socket; just glance at the pin configuration and match it to the plastic processor socket.) We closed the lever and installed the heatsink and fan.

We attached the fan's power connector to the motherboard to finish the installation.

As we expected, installing the memory module was a cinch. Locate the DIMM slots (usually situated above or to the right of the CPU) and push down on the ejector clips to unlock them. Next, grab the memory module by the edges on each end and line it up with the DIMM slot. (As with the CPU, there's only one way the module will fit.) Firmly push it into place; the clips should automatically lock in place.

Next, it was time to install the motherboard in the case. Normally, you can remove a case's I/O shield by applying a small amount of pressure with your fingertips, but our SOYO case was a little stubborn. After we opened the case, we had to use a wire cutter to remove the I/O shield because it was physically attached to the case. We screwed the motherboard to the brass standoffs but learned an important lesson in the process: Double-check that your screw size matches the standoffs' threads. Trust us, trying to remove a mobo after using the wrong screws can be a major pain.



While most I/O shields pop out with a little pressure, we had to use a wire cutter to physically remove the shield from our SOYO case.

We also installed the video card, DVD burner, and hard drive with ease. We pushed the card into the AGP slot and locked it in place by closing a sliding clip and screwing it down in our case. We did use an internal 3.5-inch bay near the bottom of the case for our hard drive to keep our IDE ribbon cable from becoming a bunched-up mess. We used both of the board's IDE connectors instead of slaving the DVD burner to the hard drive. The result was a wonderful menagerie of IDE cables that won't win this little rig any beauty contests.

In our last step of the physical build, we attached our case's and power supply's wires to the motherboard. You'll definitely want to consult your mobo's user manual to match each wire/cable to its proper connector. There are plenty of small connectors for the case's front USB ports, power and hard drive LEDs, and internal speaker, which equates to plenty of opportunities to connect one to the wrong header. Misplaced connectors can cause problems ranging from not receiving a POST screen to making a fresh order of motherboard toast. In other words, be careful.

To POST Or Not To POST

Although we consider ourselves seasoned PC vets, we couldn't even clear the first hurdle after powering on our system—getting a POST screen. Our CPU fan was whirring away, so that wasn't a concern. After confirming our video card wasn't DOA, we realized we had forgotten to connect our power supply's ATX 12V cable to the motherboard. We connected it, and everything worked. Our mobo recognized our CPU was a 2.4GHz Celeron and that we had 256MB of RAM installed.

We installed WinXP after we succeeded in getting a POST screen. We didn't have to make any changes to the BIOS to boot from the install disk, but that may have been because we chose not to install a 3.5-inch floppy drive. You may have to do a little work in the BIOS to get WinXP to boot from a CD-ROM drive. We did encounter one anomaly during the installation: Our monitor flickered on and off for about two seconds on two or three occasions. While we didn't notice any subsequent errors, it was still a concern.

Designated Drivers

While the mouse, keyboard, LAN, and USB ports worked perfectly during our first WinXP startup, our onboard sound rig gave us the silent treatment. We inserted the mobo's CD and clicked C-Media AC'97 Audio Driver And Application to install the mobo's drivers, and suddenly we had sound.

Because the users manual for our graphics card was for the Radeon 9000 chipset, we were worried that our drivers wouldn't match, either. Thankfully, the CD contained the proper drivers. We clicked ATI Easy Install and followed the on-screen instructions.

We hit a few bumps installing software for our DVD+RW drive, but everything eventually ironed itself out. We inserted

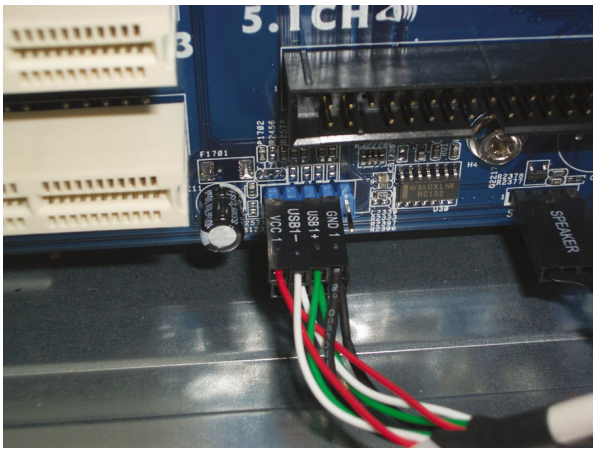
Watch Out

We knew you'd be suspicious if we told you our budget build went off without a hitch. And you'd be right. In truth, there were times when we felt like Pitfall Harry traversing his Atari jungle.

The ASROCK motherboard supports Dual Channel Memory Technology, but you must have identical memory modules in each color slot to utilize the technology. This wasn't an issue with our measly 256MB single stick but it matters when you start adding more RAM. Make sure you have identical modules in the two blue slots (DDR1 and DDR3) and the two black slots (DDR2 and DDR4). Dual Channel Memory Technology will work fine if you have different RAM in the blue and black slots, however.

As it turns out, our precious little mobo is a little finicky about AGP graphics cards. Don't use a 3.3V AGP card on the AGP slot of this board unless you like toasted motherboard for breakfast. And while we're on the subject of graphics cards, the Sapphire card we used had its jumper positioned for a PAL TV-Out signal. We moved the jumper to NTSC, which is the signal American TVs use. This setting should only affect the card if you use its TV output; theoretically, your monitor should work regardless of the jumper's position. ▲

the WinCinema CD and followed the on-screen instructions to install both WinDVD Creator Plus and WinDVD 4. But installing Nero Express was another story. When we inserted the Nero Express CD and clicked the Install option, we received Drive Not Ready and Unknown Execution Error messages on separate occasions. We took the "If at first you don't succeed, be stubborn" approach, kept trying, and eventually installed the software. We clicked Nero Media Player and In CD and installed those applications without issue.



It's only a small step in the process, but connecting wires to the right headers can avert major headaches down the road.

Installing drivers for the 8-in-1 reader/writer is optional, but helpful. WinXP immediately recognized the device, but it didn't label each slot when we clicked My Computer. We inserted the mini-CD and opened the Driver folder. We opened the GL_ReaderDriver_122_XP folder and clicked the Install icon. We clicked Yes and OK, and two letter abbreviations above each icon differentiated the drives. (For example, "SD" appeared over the SD reader icon.)

Testing

Once we had our belle gussied up for the ball, we took her out on the dance floor to see how graceful she was. We played Halo, watched a scene from "The Matrix," burned a DVD, and ran 3DMark03 and PCMark2004 benchmarks.

Our DVD burner performed well, playing smoothly without skipping or falling out of sync. Audio was weak, but then, we didn't expect too much with these speakers.

A Tale Of Two Video Cards

Attention budget gamers: 30 bucks will make or break your budget rig when it comes to gaming. Remember that 64MB Sapphire Radeon 7000 card? At a resolution of 1,024 x 768, it scored a 60 on 3DMark03. Yep, 60. The 128MB ATI Radeon 9200 at the same resolution returned a score of 1119. When we played Halo on the Sapphire card, it's a pretty safe bet that, somewhere, Microsoft's game designers wept. Technically you *can* play it, but we were minutes from chucking our PC out the window and buying an Xbox.

The gap between PCMark04 scores wasn't nearly as large. Our system scored 2276 with the Sapphire card and 2496 with the ATI card. Clearly, a faster graphics card won't make much difference with other computing tasks. If you're thirsty for gaming on your budget rig, the extra money is a wise investment.

Final Remarks

The ATI card we borrowed made all the difference. At $69, we actually would have had enough money to buy one for our rig. Then again, the Radeon 7000 worked fine for any application that wasn't graphics-intensive.

While we're generally not too wild about mail-in rebates (with policies that range from stringent to sketchy), it's really the best way to find decent equipment and stay under a $500 price limit.

In the end, we were pleased with our budget Intel-based system. If you want a computer that can handle basic tasks such as Web browsing and applications such as the Microsoft Office suite, our system turned out to be an excellent machine for the money. RS

by Vince Cogley

Parts List

Component	Model	Price	Notes
Case	SOYO Dragon	$20	After $40 mail-in rebate
Power Supply	350W Maxpower PSU	$0	Included with case
Motherboard	ASROCK P455FX	$48	
Processor	Intel 2.4GHz Celeron with heatsink and fan	$72	
Memory	256MB Corsair Value Select RAM	$51	
Hard Drive	Maxtor DiamondMax Plus 7,200rpm	$48	OEM
Video Card	Sapphire 64MB Radeon 7000	$37	
Sound Card	Integrated into motherboard	$0	
Network Card	Integrated into motherboard	$0	
CD Drive	See DVD+RW Drive	$0	
DVD-ROM/ CD-RW Drive	See DVD+RW Drive	$0	
DVD+RW Drive	BenQ 12X/4X/4X DVD+RW Drive	$40	OEM; After $40 mail-in rebate
Monitor	Dell 17-inch CRT monitor	$60	Refurbished; After $20 mail-in rebate
Speakers	SOYO Dragon	$0	Included with case
Keyboard	SOYO Dragon	$0	Included with case
Mouse	SOYO Dragon	$0	Included with case
Removable	HEISEI 8-in-1 External		
Storage Drive	Card Reader/Writer	$13	
OS	Windows XP Home	$64	On sale. Clearing out SP1 before SP2 release.
Total		**$452.43**	

Best Midrange AMD PC For Under $1,500

The Best Of Both Worlds

Build #3 Skill Level: 1 **2** 3 4 5 *Apprentice*

Although this midrange system won't impress budget-minded users or power junkies, it isn't a PC with an identity crisis by any means. In fact, we were particularly excited about this system because we weren't restricted by a tight budget or the need for mind-blowing speed. If you build a midrange system with an eye on the moment but the future in mind, your PC will always have "just enough" power, speed, and storage.

Goal

No matter what components we buy, we'll need to upgrade our PC someday. But unlike budget users, we have some extra cash, much of which we put into components that can last for a long time, such as the case.

Our system can't boast the very latest components, but when those high-performance (and high-price) parts give way to even newer technology, they'll fit quite comfortably in our system. We wanted to build an AMD-based PC for less than $1,500 that would hold its own for now and let us upgrade when that time comes.

Background

With those goals in mind, we jotted down a list of computer components (lest we forget a particularly expensive type of item that would throw off our budget) and then jumped onto the Internet.

We started our shopping spree with the case, which is one of the most important pieces of an upgradeable system. Processors and motherboards will come and go, but you'll have this case for years. If you skimp on the case, you'll hate upgrading your computer, and we just can't bear the thought of that. We found several roomy, full-tower cases, but we wanted a smaller footprint, so we searched for an appropriate midtower case. We planned on using a standard motherboard, so we checked each case's description to make sure it supported ATX-sized motherboards.

The Antec Sonata, sporting a shiny black finish and two bright-blue front panel LEDs, caught our attention right away. The Sonata's front panel has dual USB 2.0 ports, a FireWire port, and audio ports, which means you can connect mobile peripherals, such as digital cameras and music players, without reaching around to the back of the case.

We also liked the interior, which, although tight, looked like it would let us easily remove items later (a crucial characteristic for our upgradeable PC). As it turned out, we were right; this is one of the most upgradeable midtower cases we've seen.

Watch Out

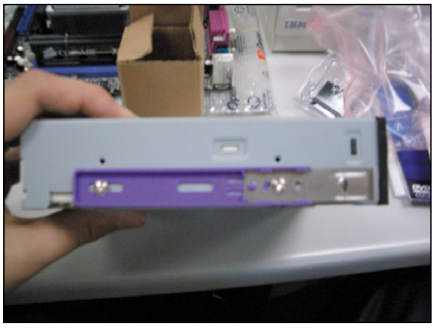
Although processor manufacturers often place heat-dissipating cases over the cores of their processors, CPUs still generate enough heat to destroy themselves. (AMD doesn't cover its Athlon XP cores at all, which makes them particularly toasty.) As a result, your heatsink/fan combo is one of your computer's most important devices. If you don't put the heatsink onto the CPU, or if you forget to plug the fan's connector into the motherboard's CPU fan header, your CPU will quickly cook itself.

In most cases you won't have any trouble spotting the CPU fan header, which will probably have the words "CPU FAN" printed near it. Unfortunately, motherboard fan headers usually look alike. We were disappointed to see that AOpen put a standard system fan header (marked "SYS FAN") right next to the CPU fan header. You can easily put the CPU fan connector on the wrong header if you're not paying attention, so double-check your CPU fan connection before you power on your computer for the first time. ▲

We were glad to see that the Sonata includes a quality PSU. The TRUE380S PSU pumps out 380 watts (plenty of power for our PC) and has a single fan, which makes it ultra-quiet.

We crossed the PSU off our list and then searched for a processor. Although we don't have any complaints about AMD's Athlon XP line, we hoped to buy an Athlon 64, which offers 64-bit processing

Sure it looks tidy right now, but just wait until we remove those twist ties.



We screwed the runner to the DVD-RW drives' top two holes first, but the drive didn't fit into the bay, so we ended up attaching them to the bottom set of holes.

(instead of the Athlon XP's and Intel Pentium 4's 32-bit processing) and built-in antivirus features. Current software doesn't take full advantage of 64-bit processors, and the CPU's antivirus capabilities will lie dormant until Microsoft releases Windows Service Pack 2. (*NOTE: SP2 was released shortly before press time.*) We decided to buy the retail version because it included a heatsink/fan combo.

Unfortunately, AMD recently changed the Athlon 64's design. The most recent models have 939 pins (the first Athlon 64s had 754-pin designs). Our budget couldn't handle the latest processors, so we bought the 754-pin Athlon 64 2800+. There are plenty of faster processors that have the same design, which means we'll be able to upgrade the processor at least once before we switch to the 939-pin design. However, when we do eventually upgrade to a 939-pin processor, we'll need to buy a new motherboard; the two processor types require different motherboards that can accommodate their pin designs. You can plan only so far ahead.

Next, we chose the AOpen AK89 MAX motherboard, which supports our processor and the latest memory. At $117 it isn't especially cheap, but we don't plan to buy another new motherboard until we've completed several other upgrades, so we selected a mobo that can handle future components. We tossed a twin pack of 512MB PC3200 DDR SDRAM DIMMs (for a total of 1GB of ultra-fast memory) into the motherboard's memory slots. The board doesn't require identical DIMMs, but we bought them anyway; if we upgrade later to a board that has dual-channel memory technology, we can use these DIMMs again. We're not sacrificing any performance now, and we'll gain performance later. We also bought a 160GB hard drive, which offers plenty of storage for SOHO use and takes advantage of the motherboard's SATA ports.

We chose an OEM version of the Sapphire ATI Radeon 9800PRO, which meant that we received only the card (wrapped in bubble wrap) and the driver CD. We didn't need any extra software that might accompany the retail versions of our components, so we saved some cash by buying OEM versions when they were available. We also bought a DVD-RW drive, which lets us burn CDs and DVDs and lets us watch DVDs.

The motherboard has an integrated sound card, but we haven't met an on-board chip that can compare to Creative Labs' justly famous soundcards. We chose the Audigy2 ZS and coupled it with a 5.1-speaker Creative Labs system. If we ever upgrade to a 7.1-channel system, our sound card will support it.

Although flat-panel monitors eat up less desk space, they cost much more than traditional CRT monitors, so we skipped them and chose an inexpensive 17-inch monitor. The USB flash drive solved the last piece of our computer puzzle. At 64MB, it can store many times more data than a standard floppy disk, and it's just as easy to use. In fact, we only bought the floppy drive because we knew that we would use it to load the hard drive's drivers during the Windows installation.

The Build

Once our components arrived, we unpacked them and then placed every manual in a pile. You'll find yourself referring to manuals often while you're building the system, so save yourself some time by keeping them close at hand. Once we checked all of our items for any obvious defects or missing parts, we installed our DVD-RW and floppy drives.

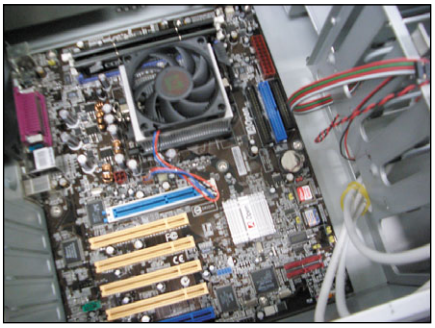
Installing the drives. Thanks to the Sonata's drive runners, installing the drives was a snap. We popped off one of the chassis' 5.25-inch bay covers and then removed the drive runners (which Antec cleverly stored against the inside of each bay cover). We screwed the driver runners to the drive so that the metal tabs were near the front of the drive and then slipped the drive into the 5.25-inch bay until the metal tabs locked. How's that for easy? When we upgrade to a different drive, we'll be able to remove this drive by pressing the tabs and

System Notes	
Outstanding Features: Our system boasts a strong video card, which means it can handle 3D animation well. We also like its 1GB of PC3200 memory, which gives the system some extra oomph.	
Weak Link: Thanks to its Ethernet port, the PC supports broadband connections, such as cable and DSL. However, it leaves dial-up users in the lurch.	
Dimensions (inches; Tower Only): 16.75 x 8.13 x 18.25	
Weight (lbs.; Tower Only):	28.4
Benchmarks	
We ran PCMark04 (version 1.2.0, with Windows Media Player 9) and 3DMark03 (build 340, with DirectX 9.0b) at default settings.	
PCMark04	3616
CPU Score	3374
Memory Score	3404
Graphics Score	4119
HDD Score	4427
3DMark03	5562

pulling the drive out of the case. We didn't attach the IDE cable or power cable yet because we wanted to keep the cables out of the way until we had finished installing the rest of the system's components.

The two smaller 3.5-inch bays didn't include runners. Instead, the case included a single two-bay drive sled. We pressed the sled's tabs, pulled it out of the chassis, and then removed one of the two bay covers. Next, we screwed the floppy drive into the top bay and then popped the sled back into the chassis.

We were surprised to see that the hard drive bays point the ends of the drive toward the side panels instead of the front and back panels. As with the floppy drive bays, the hard drive bays include sleds. We screwed the hard drive into the sled so that the end of the drive that housed the power and data connectors pointed into the case (away from us). If we had turned the drive around, we would have had a hard time closing the side panel. Each sled has four rubber-lined holes that let us slip special screws (included with the chassis) into the hard drive's four holes.



That's a tight fit. Despite the case's small interior, we didn't have any trouble adding components.

Installing the CPU. We could have installed the CPU after we screwed the motherboard into the chassis, but we wanted plenty of elbowroom while dealing with our computer's most sensitive component. We pulled out the mobo and then placed it on top of its protective bubble wrap bag.

Unlike Athlon XP-based motherboards, Athlon 64-based motherboards have a backplate that attaches to the back of the motherboard (behind the CPU socket) and a retention frame that surrounds the CPU socket. The mobo includes the backplate and retention frame, so we followed the motherboard's instructions. We peeled the liner off the backplate and stuck it to the motherboard so that the backplate's holes lined up with the mobo's holes. We then placed the retention frame onto the top of the motherboard and used the included screws to tie it all together.

Next, we lifted the CPU socket's lever to open the socket's pinholes and then opened the small plastic package that surrounded the CPU. We held the CPU over the socket and matched the small triangle on one corner of the CPU to the small triangle on the socket edge before we (gently) dropped the CPU into the socket. We put a hand into a plastic bag and carefully nudged the CPU into place.

Once we were satisfied with the CPU placement, we lowered the socket lever and removed the clear plastic cap from the aluminum heatsink. The heatsink had its own fan and a square thermal pad, so we didn't have to add thermal paste. We lowered the heatsink onto the CPU and slipped one of the heatsink's clips over the retention plate's hooks. Next, we grabbed a flat-head screwdriver and slipped it into the other clip so we could apply pressure. We pressed the (somewhat unwilling) clip until it slipped over the head of the hook and then lowered the lever next to the first clip. We plugged the heatsink fan's small connector into the motherboard's CPU fan header.

Installing the motherboard. Before we placed the motherboard inside the case, we popped out from the back of the case the metal faceplate that protects the mobo's I/O connectors. We replaced it with the new faceplate, which turns out to be a better fit for the connectors.

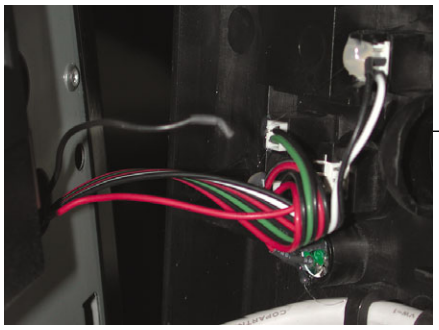
We screwed the chassis' brass standoffs (screws with hollow tops that accept other screws) into the case, placed the motherboard on the standoffs, jiggled the motherboard's I/O ports into the faceplate, and screwed the motherboard into the standoffs. Don't ignore the standoffs; if you screw the motherboard directly into the case and power it on, you may find yourself shopping for a new motherboard.

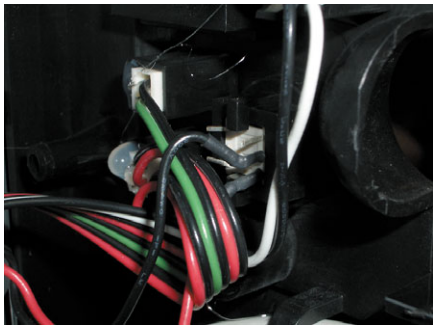
Time-saver

Thanks to our Antec Sonata's special hard drive cages and optical drive runners that let us slide the drives into the case from the front, we could have installed the motherboard before or after we installed those components. However, many small cases lack the Sonata's design refinements. If you use a small case, install the optical drives, floppy drive, and hard drives before you install the motherboard. By skipping the motherboard, you can easily install the drives from inside the case; if you install the motherboard first, you'll have to negotiate the bulky heatsink, the AGP card, and any PCI cards. ▲

We looked at the motherboard's memory slots and found the slots marked DIMM1 and DIMM2. We pushed the memory into these slots. Next, we plugged our video card into the AGP slot, which stands just above the board's PCI slots. We locked the slot's small lever and then moved on to our sound card, which we pushed into a PCI slot. We unscrewed the slot covers at the back of the computer and then used the same screws and holes at the ends of the bay slots to lock our cards into place.

With our components inside the case, we began connecting the front panel connectors to the motherboard. The front panel cables had multiple connectors, so we referred to the motherboard manual, which helped us match the connectors to the pins. Unfortunately, Antec didn't mark the similar-looking FireWire and USB cables. We spotted the USB cable by comparing the two cables to one of the motherboard's included USB D-brackets (which had a cable that could connect to the motherboard). We plugged a four-pin power connector into our video card and then plugged the IDE cable into our optical drive and motherboard. Thanks to the drive's runners, we were able to pull the drive toward us, which gave us enough room to reach into the hard drive area and then plug in the SATA and power connectors.





We were nervous when we couldn't boot our computer. It turned out that we had accidentally pulled a power switch cable from its pin.

Once we finished connecting the power and data cables, we closed the chassis door, attached the monitor and other peripherals, pressed the power button, and—pressed it again because the computer didn't power on. We opened the side panel and tried again, watching for any fan movement, but nothing happened. However, we saw a motherboard light, which meant that power had reached the board. We looked for loose connections and finally found the culprit: One of the cables that connected the power button to the motherboard had popped off its pin. We had probably pulled it loose while installing the components. We slipped it back onto its metal receiver, used a cable tie to hold it in place, and then pressed the power button again. Success!

We installed Windows XP without a hitch. We placed the CD into our DVD-RW drive, powered on our system, and then pressed F6 when Windows Setup asked us to install SCSI/RAID drivers. Windows Setup continued to load files and then displayed this message: Setup Could Not Determine The Type Of One Or More Mass Storage Device(s).

We pressed *S* to select the option that begins with: To Specify Additional SCSI Adapters, CD-ROM Drives, Or Special Disk Controllers… and then inserted the motherboard's floppy disk (which includes the SATA drivers). We selected Silicon Image SiI 3114 SATARaid Controller For Windows XP/Server 2003, selected our hard drive, and then selected Format The Partition Using The NTFS File System. Windows loaded our SATA drivers and then finished the installation.

When Windows booted for the first time, we immediately connected our PC to the Internet and then used Windows Update to apply Microsoft's patches. Microsoft releases patches every month that add features and (more importantly) fix problems or security holes. We clicked Start, All Programs, Windows Update. Internet Explorer opened and then displayed the Windows Update page, which scanned our computer and suggested updates. We installed the updates and then grabbed our stack of CD-ROMs, which contained our devices' drivers. We installed all of the drivers and loaded CyberLink PowerDVD 5.0, which accompanied our DVD-RW drive. When our PC played a DVD without trouble, we knew it was ready for benchmarks.

Testing

After watching a DVD, we tested the system by attaching the flash drive to each USB port and then transferring files from the USB drive to the computer. We weren't surprised that the motherboard's USB ports worked, but we were glad to see that the front panel USB ports also transferred the flash drive's files. Next we ran several benchmarks to test the system's performance in game and office/home use settings.

We ran Futuremark's PCMark04, which ran several apps, including antivirus, encryption, and audio conversion programs. Our new system scored 3616, a bit lower than we expected; our Intel midrange system had scored 4367.

Next, we ran 3DMark03 to test the system's gaming ability. We were surprised to find that our PC scored 5662, higher than we expected, and much higher than the Intel midrange system's 2555. We suspect our heavy-duty video card helped our 3DMark03 score.

Final Remarks

Aside from the loose power cable, we didn't have any trouble building our system. We love the case, which let us easily add and remove components as we connected the dozens of power and data cables.

Although our system can't stand up to the big kids on the block, it'll hold its own in the midrange world. It's easily upgradeable, provides excellent audio and video, and is fast enough to handle the latest video games and applications. RS

by Joshua Gulick

Parts List

Component	Model	Price
Case	Antec Sonata (includes PSU)	$99
Motherboard	AOpen AK89 Max	$117
Processor	AMD Athlon 64 2800+	$187
Memory	1GB Corsair XMS PC3200 (512MB x 2)	$254
Hard Drives	160GB Seagate ST3160023AS (OEM)	$120
Video Card	256MB Sapphire ATI Radeon 9800PRO (OEM)	$209
Optical Drive	Lite-On SHOW-812S	$80
Monitor	ViewSonic 17-inch CRT E70B	$109
Floppy Drive	Generic	$8
Soundcard	Creative Labs Audigy 2 ZS	$88
Mouse & Keyboard	Logitech Cordless Navigator Duo SE	$55
Speakers	Creative Labs SBS560 5.1	$56
Operating System	Windows XP Home	$90
USB Key	Kingston 64MB Data Traveler KUSBDTI/64	$26
Miscellaneous	Cable Ties	$2
Total		**$1,500**

Best Midrange Intel System For Under $1,500

Power For The Budget-Minded

Build #4 Skill Level: 1 2 3 4 5 ***Journeyman***

While it's true that $500 will buy a lot of computer, it's also always been true that $1,500 will buy more. If all you want is to send email and surf the Web, a $500 machine is probably all you need. Spending a little more on your system, however, will let you get more from your system for longer. In this article, we build a $1,500 midrange Intel system.

Goal

Our aim was to construct a good renaissance system for less than $1,500 that could tackle a variety of common chores. We wanted an Intel-based system that could handle gaming, but we didn't want to focus exclusively on gaming because we're building gaming rigs later in this issue. Instead, we wanted a family computer that would be a good platform for managing household finances, manipulating digital images, watching television, and even editing home movies.

Background

In order to handle more complex tasks, we needed a fairly powerful processor, but obviously price is still a major consideration. Intel's 3.0C GHz Pentium 4 seemed to fit the bill well. This CPU uses the older Northwood core, which isn't necessarily a bad thing. The newer Prescott core seems to run hotter and it doesn't necessarily perform much faster at the same clock speed. So opting for the 3GHz Northwood seems to be the way to go. We found a 3.0C GHz P4 for $209.

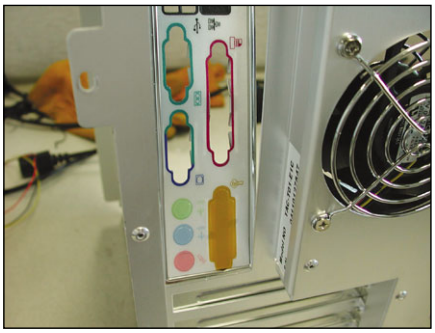
We bought an OEM P4, which lacks the stock heatsink and fan normally bundled with retail versions of Intel's processors. We would've saved a few bucks if we opted for the retail package, but buying an OEM model gave us the opportunity to upgrade our heatsink and fan. We settled on the OCZ Eliminator 2 heatsink and fan. Unlike Intel's aluminum stock heatsink, the OCZ Eliminator 2 is made entirely of copper, which is a better conductor of heat than aluminum. This heatsink should do a better job of keeping our P4 running cool.

Intel's new 915 and 925 chipset motherboards provide some impressive features, but they use the new LGA 775 socket rather than the traditional 478 socket we need for our 3GHz Northwood. Motherboards based on the new chipsets would've been too expensive for our midrange system, anyway. Instead, we looked for a motherboard with Intel's 865PE chipset. The 865PE is similar to Intel's high-end 875P chipset, but it lacks support for ECC (Error Correction Code; protects against read/write errors to RAM, but because it's more expensive and slower than non-ECC memory, it's used almost exclusively on servers) memory and PAT (Performance Acceleration Technology). We didn't need or want the added expense of ECC memory on a desktop system, and PAT often isn't worth the premium you pay for 875P motherboards.

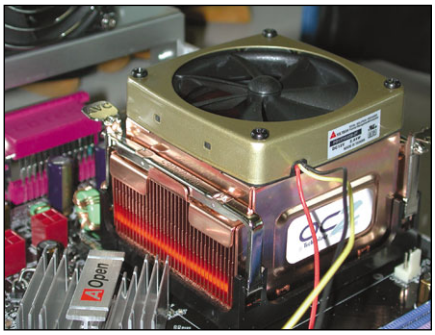
We settled on an AOpen AX4SPE-UN motherboard. We used two sticks of 256MB PC3200 DDR SDRAM memory to take advantage of the motherboard's dual-channel memory support. Like most recent motherboards, the AX4SPE-UN includes integrated Ethernet and audio, so there's no need to pay extra for a sound card and NIC. The AX4SPE-UN we decided on included a basic 10/100 Ethernet port, but an AX4SPE-UL model is available with Gigabit Ethernet. In the end, we didn't think Gigabit Ethernet was worth the extra money when building a midrange system.

We could've saved money on a video card by opting for an Intel 865G motherboard, which includes integrated graphics. We went with the 865PE motherboard, however, because we wanted to add an ATI All-In-Wonder Radeon 9600. The All-In-Wonder includes TV and A/V inputs as well as A/V outputs. Using the included software, you can watch television on your PC, record live TV, or use the channel guide to record upcoming shows. You can even use the All-In-Wonder card to capture old home movies for editing on your PC.

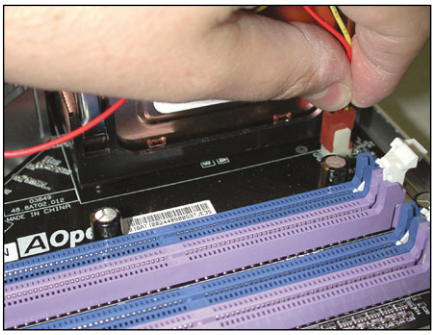
From a performance standpoint, the Radeon 9600 is far from ATI's high-end X800 series, but it would be enough to



Punch out the faceplate on the back of the motherboard tray to make room for the custom faceplate included with your motherboard.



Our all-copper heatsink looks sharp, and it will keep the processor cooler than the stock Intel heatsink included in retail bundles.



Be sure to connect the fan's cable to the nearby fan header.

provide decent performance in most games. If you play games more than occasionally, you can opt to do without the video capture features of the All-In-Wonder and buy a slightly better video card. For us, the All-In-Wonder Radeon 9600 provided the features we wanted for a reasonable price ($172). If you're not too fond of watching television or movies on your monitor, use the A/V outputs to play back video on a nearby television set.

Prices on DVD burners have come down significantly in the past few years and at $68.99, the 8X NEC DVD+/-RW was simply too tempting an option to pass up. We thought a DVD drive would complement our All-In-Wonder card nicely. Using the video card, you can record your favorite television shows and then burn them to DVD for posterity. Likewise, you can capture and edit your old home movies using the video card and then record your movies to DVD. Again, we bought the drive OEM, so we didn't receive any additional software with our drive and we bought only the software necessary to get the system up and running. If you want to take full advantage of the DVD burner, you'll want to invest in some DVD authoring software such as Sonic's MyDVD. One reason we opted for the NEC drive is because we were able to find a model in silver, which matched the finish of the case we had decided on.

We also ordered a silver Mitsumi floppy diskette drive. We know, floppies are extremely dated, but for $10.90, the Mitsumi provides a little extra bit of comfort for a small price. Floppy drives are still useful for troubleshooting (using a boot disc, for example), and they're sometimes required to install Windows on systems with SATA drives.

Next, we added an 80GB 7,200rpm Hitachi SATA hard drive for $74 (that works out to less than 0.1 of a penny per megabyte). We bought the drive OEM, meaning we didn't get any cables included with the drive. Usually, you get at least one SATA cable with the motherboard, but the AX4SPE-UN only came with an IDE and floppy cable, so we were forced to buy a SATA cable at our local computer store.

We spent $140 on our Cooler Master Wave Master case. Granted, $140 is on the expensive side for a midrange system case, especially considering that it doesn't even come with a power supply (an additional $49 for a Thermal Take W0009R 420W PSU). The Wave Master, however, is a well-designed case that's a pleasure to work on. You'll make up for the extra cost in terms of reduced frustration when it comes time to build the system. Besides, the Wave Master has an excellent metallic finish highlighted with blue LEDs that looks great, and looks matter, right?

We rounded out our system with a Viewsonic KP-202 Office Keyboard ($25) and a Viewsonic KBM-MC-201 optical mouse ($12). The keyboard includes a number of handy buttons for launching common Windows applications such as Word and Excel. (Unfortunately, you can't map the buttons to launch other software.) We also added a 17-inch Samsung SyncMaster 170N LCD in black ($379). The flat panel display will be easier on the eyes than a standard CRT, takes up less space, and just looks better than a bulky CRT. Finally, we added AOpen's MS-915 5.1-channel surround-sound speaker system for $64.

The Build

Once all the parts arrived, we set everything out on a desk in front of us and began the process of assembling our PC. Unfortunately, our enthusiasm sometimes got in the way of good judgment. That's not to say we ran into any real disasters assembling the system; in fact this was a fairly trouble-free build. Nonetheless, a little forethought would've made things easier. For instance, we learned it was best to install the hard drive *before* inserting the motherboard tray.

Case. We started by unpacking the case, removing the three thumbscrews securing each side panel, and removing both panels. Unfortunately, the one feature lacking from this case was removable drive bays, so we needed access to both sides of the case in order to secure our drives. The hardware included with the Wave Master (screws and instructions) was located in a box occupying the power supply mount. We used a screwdriver to remove the four screws securing the PSU faceplate to the back of the system and removed the box. Finally, we removed the four remaining thumbscrews on the back of the system, allowing us to pull the motherboard tray from the back of the system.

Motherboard, processor, and RAM. In order to get our motherboard to fit

properly, we had to punch out the riser faceplate on the back of the motherboard tray. We inserted the faceplate included with our AX4SPE-UN in its place. Before we could secure the motherboard to the motherboard tray, we needed to install standoffs. We screwed six standoffs into the motherboard tray in positions that lined up with screw holes on the motherboard. We used a screwdriver and six of the screws included with our case to secure the motherboard.

Once the motherboard was secured to the motherboard tray, we inserted the processor into the ZIF socket. The OCZ Eliminator 2 comes with its own heatsink mount, which we were able to discard because the AX4SPE-UN comes with a heatsink mount already installed. We placed a small amount of thermal paste in the center of the processor's heat spreader and then placed the heatsink over the processor and twisted the heatsink to the left and right as much as possible. Next, we used the included clips to secure the heatsink to the heatsink mount and connected the fan's cable to the nearby fan header. Finally, we installed both sticks of PC3200 DDR SDRAM into the proper memory slots.

Video card. We found it easiest to install our only expansion card, the ATI video card, at this point. Before we inserted the card, we removed the second thumbscrew from the top and removed the guard protecting the expansion slot. The AGP slot has a slider to secure the card; we pulled the slider toward the front of the case, inserted the card into the AGP slot, and then pushed the slider back toward the back of the case to secure the card. Finally, we tightened the thumbscrew to finish securing the card.

If we wanted to record audio with our television shows (and we did), we needed to connect the ATI card to the CD-IN port on our motherboard. We used a spare audio cable to connect the 4-pin mini connector on the ATI card to the larger 4-pin connector near the bottom center of the motherboard.

Drives. We found it was easiest to install our DVD burner, floppy, and hard drive before reinserting the motherboard tray. We removed the screw on each side of one of the 5.25-inch drive bays and then reached inside to punch out the faceplate. We then slid the DVD burner into place and secured it with four screws. We followed the same procedure to mount the floppy drive in the proper 3.5-inch drive bay.

Our Wave Master case came with two intake fans installed at the bottom of the case. We had to install the hard drive between the floppy drive and the fans, as the fans prevented the drive from sliding all the way into place. We secured the drive, once again using four screws.

Motherboard tray and connections. Inserting the motherboard tray is fairly straightforward. Once secured with thumbscrews, we could begin wiring the motherboard to the case.

Using the included motherboard manual, we connected the power switch, reset switch, speaker, and HDD LEDs to the motherboard. The Wave Master's power LEDs don't connect to the motherboard.

Next we connected the USB ports located in the top of the case to the USB header. Our motherboard didn't have a FireWire header, so there was nothing to connect the FireWire port to. Finally, we connected the rear case fan to a nearby system fan header on the motherboard.

Power supply. Once we had finished with those initial connections, we installed the PSU by sliding it into the rack in the upper-rear corner of the system. We then secured the PSU faceplate to the system and used additional screws to secure the PSU to the faceplate. We connected the ATX and 12V connectors to the motherboard and connected the standard 4-pin Molex connectors to the two power LEDs, DVD burner, floppy drive, and front intake fans. We connected the SATA power connector to our SATA drive.

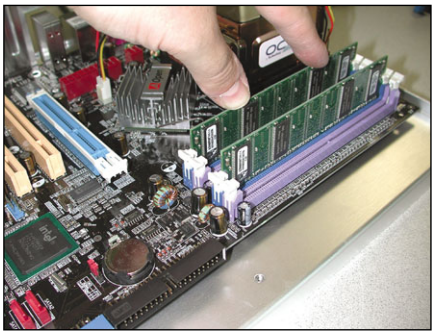
Once you've made the power connections, you can connect the drives to the motherboard. We used the IDE cable included with our

System Notes

Operating System	Windows XP Home
Processor	3GHz Intel Pentium 4
RAM	512MB
Bus Speed	800MHz
Hard Drive	80GB SATA
Optical Drive	8X DVD±RW Drive
Connectivity	10/100 Ethernet
Video Card	ATI All-In-Wonder Radeon 9600
Video RAM	128MB
Monitor	17-inch SXGA LCD
Sound Card/Speakers	5.1-channel Surround Sound
Chassis Size (inches)	21.3 x 7.8 x 18
Weight	29.56 lbs
Benchmarks:	
3DMark03	2555
PCMark04	4367
CPU Score	4531
Memory Score	4389
Graphics Score	1849
HDD Score	4573

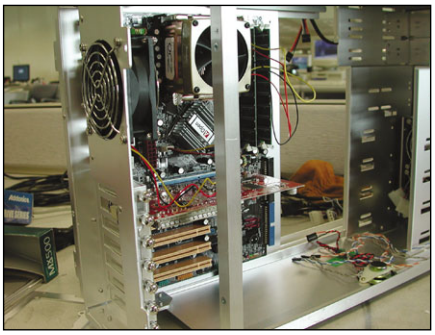
Parts List

Component	Model	Price
Case	Cooler Master Wave Master	$140
Power Supply	Thermal Take W0009R 420W	$49
Motherboard	AOpen AX 4SPE-UN	$75
Processor	3.0C GHz Pentium 4	$209
Memory	Kingston 256MB PC3200 DDR SDRAM (x2)	$92
Hard Drive	Hitachi HDS722 580VLSA80 (80GB)	$74
Video Card	ATI All-In-Wonder Radeon 9600	$172
Sound Card	Integrated	$0
Network Card	Integrated	$0
DVD Writer	NEC 8X Silver DVD±RW	$68.99
Diskette	Mitsumi 1.44MB floppy (silver)	$10.90
Monitor	Samsung 170N-Black	$379
Speakers	AOpen MS-915 5.1-channel Speakers	$64
Mouse	Viewsonic KBM-MC-201	$12
Keyboard	Viewsonic KP-202 Office Keyboard	$25
OS	WinXP SP1a (OEM)	$90
Heatsink	OCZ Eliminator 2	$28
Total		**$1,488.89**



Installing both memory modules in the blue sockets will allow the motherboard to take advantage of dual-channel memory.

Install the DVD burner, floppy drive, and hard drive by securing each drive to the proper bay using four of the included screws.



After you've installed the drives, insert the motherboard tray and secure it to the case using four thumbscrews.

motherboard to connect our DVD burner to the secondary IDE port. The motherboard will automatically map your SATA drive to the master device on the primary IDE channel, so placing the DVD burner on the secondary channel will leave room for your SATA drive. Use the included floppy cable to connect the floppy drive to the motherboard. Finally, use the SATA cable to connect your hard drive to the SATA1 port on your motherboard.

Finally, we connected the keyboard, mouse, and monitor. The monitor connects to an extension cable which then connects to the back of our All-In-Wonder card.

Power on. With everything in place, you can power on your system. We noticed the system was making a lot of noise when we first turned it on and eventually realized the fan on our heatsink was causing the entire motherboard tray to vibrate. We inserted a small piece of thin cardboard to quiet the noise, but then we noticed that our drive bay door was vibrating a lot when closed. Putting the side panels back in place helped eliminate the rest of the noise.

Press DELETE to enter the setup utility and adjust the date and time. Place your Windows XP Home installation CD into your DVD burner before saving your settings and rebooting the system.

The Windows installation utility will begin automatically. Our motherboard lets you install WinXP to a SATA drive without loading any special third-party drivers. Before installation continues, you have to agree to Microsoft's EULA (End User License Agreement) by pressing F8. Unfortunately, our Viewsonic keyboard didn't register the proper keystroke when we pushed F8, so we had to use another keyboard to make it past the EULA.

Once we had Windows installed, we installed our ATI All-In-Wonder Radeon 9600 software. The software includes an applet that enables a remote control. Once installed, we connected our remote control receiver to a USB port. The remote is an RF unit, so you don't have to worry about line of sight and can hide the remote receiver behind the case.

We then installed our motherboard drivers and utilities, followed by the software included with our monitor, keyboard, and mouse. We then attached our 5.1-channel speaker system to the audio ports on the back of our motherboard.

Testing

Once we had our software installed, it was time to see how our system handled. We ran both 3DMark03 and PCMark04 benchmarks on the system. Our 2555 3DMark03 score was pretty unimpressive, but this system isn't meant to be a gaming rig and considering its features, we're not too disappointed with our 3DMark03 score. You'll still be able to play a few games on this system, but you may have to settle for a lower resolution and fewer special effects.

PCMark04 scores were about average and not too bad considering the system's sub-$1,500 price. Our overall PCMark04 score was 4367, with the 1849 Graphics score being the lowest individual component score. Our CPU scored a respectable 4531 and our mobo managed a 4389 Memory score. At 4573, the HDD score was our most impressive number.

Our video card included GuidePlus+ for finding and recording television programs. The GuidePlus+ interface lacks the charm of a TiVo, but it's effective enough. Simply click any program currently running to change channels. To record a program, right-click the program in the channel guide, select Record, and choose a recording quality (DVD, Home Theater, Portable, or VideoCD). A 30-minute program recorded on the Home Theater setting takes up roughly 660MB to 690MB, while a 30-minute program recorded at the Portable setting uses about 240MB. The ATI software can handle DVD playback, so there's no need to invest a DVD decoder to watch movies.

Final Remarks

For a grand total of $1,488.89, we managed to create a versatile system the whole family can enjoy. The ATI All-In-Wonder card doesn't deliver too much in terms of performance, but its features and price more than make up for its lack of performance. The DVD burner is a nice touch. Even without the DVD authoring, you can still burn video files to a DVD or CD-RW. You may not be able to play them on a standard DVD player, but you'll be able to play them back on your PC. RS

by Chad Denton

Best High-End AMD PC For Under $2,500

Conquer Digital Worlds In Style

Build #5 Skill Level: 1 **2** 3 4 5 ***Apprentice***

Our high-end system boasts powerful sound and video cards and the new 939-pin AMD Athlon 64 3800+.

Budget and midrange computers make solid Web surfing machines, and a midrange PC makes a decent gaming machine, but neither system can do justice to resource-intensive tasks such as CAD, DV (digital video), and photo editing. Our high-end system has more storage, more processing power, and a better optical drive than the budget and midrange systems, which makes it an excellent home- or small-office system. That said, our system isn't a workstation; if you want more DV power than this system affords, take a look at our article "Best Heavy-Duty Graphics/CAD Workstation For Under $3000," page 48.

Goal

Of course, high-end doesn't always mean budget-free. In our case, our editors asked us to build a monster system without spending more than $2,500. We did just that, and we were surprised to find that we made very few sacrifices to stay in the black.

If you have more than one computer user in your family, you already know that your ideal business PC may not satisfy the family gamer or movie buff. Although the PC that meets everyone's needs may be nothing more than a dream, we took a stab at it, and we think you'll like what we threw together. Our plan: create a system that has plenty of storage (for video and audio collections), a smoking-fast video card (heavy-duty gaming), a fast processor, and a large monitor that can accommodate office spreadsheet applications such as Excel. We also hoped to house the system in an eye-catching chassis that would impress those who couldn't appreciate the components under the hood.

Background

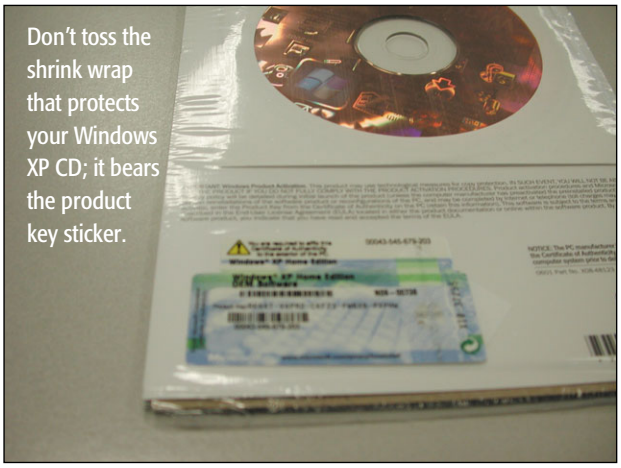
In general, we looked for items that were faster, bigger, or more powerful than the components that made up our AMD midrange system, but we really liked the cheaper system's Logitech Cordless Navigator Duo SE, so we hung on to it. The Duo's wireless keyboard and mouse are stylish but simple devices that add a little spice to your desk. Unless you're completely against keyboards that have extra features, you'll like the row of shortcut keys and the modest spattering of programmable multimedia buttons. We could have jumped to the Logitech Cordless MX Duo, which includes a mouse battery charger, but at $99.95, the set would draw too much from our coffers.

We also kept the midrange system's Creative Labs Sound Blaster Audigy 2 ZS sound card. Movie buffs will like the card's THX certification, and audiophiles and gamers will like the special EAX features. Our budget didn't have room for a 7.1 speaker system when we built the midrange system, so we took advantage of the extra cash and bought the Creative Inspire TT7700, which cost a little more than double our midrange system's 5.1 setup.

AMD recently switched its Athlon 64 processors from a 754-pin model to a 939-pin model, so most motherboard manufacturers hadn't launched compatible boards by the time we hit the stores. Despite our lack of options, we quickly found a promising mobo: the ASUS A8V Deluxe. The board supports multiple RAID options and has three IDE connectors and four SATA connectors. And thanks to the VIA K8T800Pro chipset, we'll be able to

keep the board whether we upgrade to a future Athlon 64 or its super-charged sibling, the Athlon 64 FX. For the moment, we chose the Athlon 64 3800+, which boasts a 2.4GHz clock speed, a 128KB L1 cache, and a 512KB L2 cache. Many retailers offer an OEM version (which includes only the processor) and a retail version that includes an AMD-certified heatsink/fan combo. Although the aluminum heatsink/fan combo can't distribute heat as well as copper third-party models, we chose the retail version of the 3800+. We planned to run our system at stock settings, so we didn't need anything better than a stock fan. If you plan to overclock your system, you might want to look into better heatsinks or even more exotic cooling methods, such as watercooling.

We bought 1GB (two 512MB DIMMs) of Mushkin's PC3500 DDR SDRAM and then turned our attention to the video card. We picked the ASUS GeForce FX V9950 graphics card because it's powerful and supports DirectX 9. The card supports most current games at high settings and should be able to handle next-gen games with ease.



Don't toss the shrink wrap that protects your Windows XP CD; it bears the product key sticker.

Unlike the midrange system, which had one of the cheapest DVD-RW drives we could find, our high-end system includes the popular Plextor 708A. The drive includes BURN-Proof (Buffer UnderRuN Proof) technology and Lossless Linking technology; it also supports burn speeds of 4X DVD+RW and 2X DVD-RW. Unfortunately, the drive only has a 2MB buffer. We thought about the 712A, which offers slightly faster burn speeds and 6MB more buffer, but we decided to put our dwindling reserves toward a respectable amount of storage. We chose two 160GB Seagate 7,200rpm SATA hard drives.

Although we liked the midrange system's Antec Sonata, we decided to house our high-end system in a Lian-Li PC-65 midtower, which supports more fans (it includes four fans and a fan-speed controller). The front panel lacks the Sonata's front audio ports and FireWire port, but it has two USB 2.0 ports, so we're not complaining. The case has four external 5.25-inch bays and three external 3.5-inch bays, which means we'll have plenty of room when we upgrade in the future. We also liked the case's clean interior and the large side-panel window. (If you're going to drop $2,500 on components, you might as well show them off.) We also bought a single cold-cathode light which (we hoped) would add a little bling bling without being gaudy.

The Lian-Li PC-65 doesn't include a power supply unit, so we searched for a powerful but quiet PSU. Although we weren't trying to build a silent PC, we didn't want to turn the office into a wind tunnel, either. The 470W Enermax Noisetaker fit the bill perfectly and even included a rebate that dropped its price from $84 to $69.

We searched high and low, but we couldn't find a flat-panel monitor that fit our budget. We like LCDs because they free up desk space. Luckily, we found a gorgeous 19-inch ViewSonic CRT monitor that features a reasonable 0.27mm dot pitch screen and a special antireflection and antistatic coating. Sure, it's huge, but it supports a wide range of resolutions (its native resolution is 1,280 x 1,024, but it can support up to 1,792 x 1,344) and includes a three-year warranty.

Watch Out

Even if you order several OEM parts, you'll find yourself surrounded by boxes, bubble wrap, and other packing material, not to mention the components themselves and their accessories. Before you dive into the building process, find your copy of Windows XP and then locate the product key sticker. Microsoft attaches the product key sticker to the OEM version's shrink wrap. The Windows Setup Wizard requires the sticker's password, so if you toss that shrink wrap in the trash with the rest of the packaging, you'll have some digging to do.

Once you locate the sticker, remove it from the shrink wrap and then store it in a safe place. If you place the sticker somewhere on or in your computer (as Microsoft suggests), we recommend that you write down the key and store it away from your computer. If your computer is stolen, you'll still have your Windows key and CD (small consolation, we know). If you do lose your key, grab your receipt and call Microsoft's customer service at (425) 635-3311 for WinXP Home and Professional users. ▲

The Build

We kicked off our PC buildfest by unpacking every component and checking for any obvious defects. We noticed right away that our ViewSonic monitor had a small crack, which didn't bode well. Sure enough, we couldn't power on the monitor. We returned it, but not in time to use the replacement when we tested our system later. Instead, we grabbed one of our own monitors. Luckily, the monitor was our only DOA, so we collected all the installation manuals and got to work.

Unfortunately, the chassis' windowed side panel didn't have a handle. You'll need to put your hand flat on the panel and then slide it toward the back of the computer to remove it. As a result, we quickly dirtied our window with palm and fingerprints. The handleless panel aside, we didn't have any complaints about case. Every removeable item has thumbscrews, which means that you'll rarely need your screwdriver. We

were glad to see a poster that included PSU and drive installation instructions, as well as a chart that identified the case's myriad screws.

Installing the drives. The Lian-Li PC-65 doesn't have drive runners, but we didn't miss them, thanks to the case's easy-access front panel. We simply grabbed the bottom of the front panel and lifted up to remove it from the case. Next, we popped out a 5.25-inch bay cover and slid our Plextor DVD±RW drive into the bay. Once we lined up the front of the drive with the bay cover below it, we screwed the drive to the internal drive cage. When we removed the right side panel, we noticed the front panel fans' power cables, which were tucked in the corner. We moved the cables toward the center of the case so we could grab them later without removing the side panel again.

Unlike the optical drive cage, the three-bay floppy drive cage is removeable. We pulled it out of the case, removed the bay cover, and screwed the floppy drive into place. As with the optical drive, we used the remaining bay covers as guides when lining up the drive. We popped the cage into place, replaced the front panel (which easily slid over the protruding drives), and pulled out the removeable hard drive cage. The cage stores hard drives on their sides, which means you can stand five hard drives next to each other if the mood should so strike you. We took advantage of the extra drive slots by placing the two drives apart from each other, which means air will flow easier around both sides of each drive. We pointed the ends of the drives that had connectors toward the middle of the case.

Installing the CPU. One of the many reasons we like the chassis is its removeable motherboard tray. You can pull the tray free and easily access the PCI and AGP cards, the memory, and the CPU. We could have put the motherboard on the tray and then installed the CPU, but we knew that we'd need to apply some serious pressure to clip the heatsink onto the motherboard's retention frame, so we decided to put the board on a flat surface. We grabbed the mobo package's foam padding and antistatic bag and then placed the motherboard on top.

We were glad to see that ASUS installed the retention frame and backplate before it shipped the motherboard. We lifted the CPU socket's lever and then matched the small triangle on the one corner of the 3800+ to the triangle on a corner of the socket before we placed the CPU into the socket. Never force the CPU into the socket: if you can't press it in gently, make sure that your motherboard is built for your CPU. If you try to push the new 939-pin Athlon 64 into a 754-pin Athlon 64-based board, well, it won't be pretty.

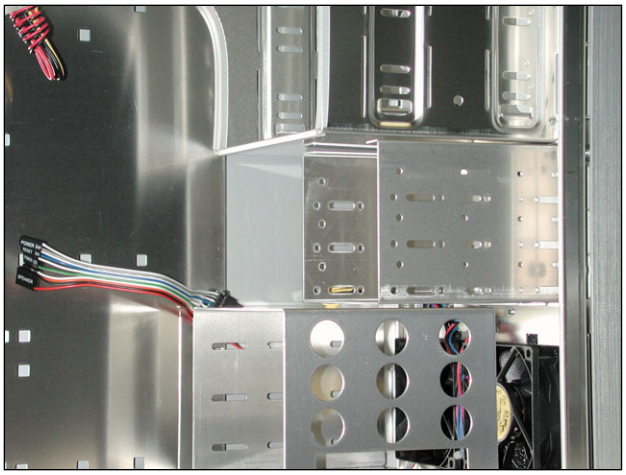
Once the CPU settled into the socket, we placed the aluminum AMD heatsink into the retention frame so that the metal clip hovered over the frame's two hooks. We grabbed the clip that had a plastic lever and then slipped the clip over the hook, but we left the lever unlocked. Next, we pushed down on the other end of the clip until it snapped onto the hook. Many heatsink clips are designed to let a builder use a screwdriver to push the clip, but this particular clip demanded finger power. We snapped the lever into place and then connected the fan's power cable to the small, 3-pin CPU fan connector. Don't forget to do this; the heatsink alone won't dissipate enough heat to prevent your CPU from overheating. In fact, we recommend double-checking the CPU fan connection before you power up the computer for the first time.

Installing the motherboard. Once we installed the CPU, we replaced the generic I/O port faceplate with the motherboard's faceplate and then pushed nine mounting nuts through the motherboard tray's holes. We placed the board on the mounting nuts, nudged it into the faceplate, and screwed the board to the tray. When we plugged our video card into the AGP slot, we noticed that we had to loosen the bay covers on either side of the card. Once we installed the card, we tightened the surrounding bay covers. The video card has a massive heatsink/fan combo that extends over the nearby PCI slot, so we jumped a couple of slots and added the Audigy ZS and the motherboard's

Parts List

Component	Model	Price
Case	Lian-Li PC-65	$109
Motherboard	ASUS A8V Deluxe	$171
Processor	AMD Athlon 64 3800+	$698
Memory	Mushkin PC3500 (512MBx2)	$275
Hard Drives	160GB Seagate ST3160023AS (x2)	$240
Video Card	ASUS GeForce FX V9950*	$260
Optical Drive	Plextor 708A	$140
Monitor	ViewSonic E90B	$169
Floppy Drive	Generic*	$8
Sound Card	Creative Labs Audigy2 ZS	$88
Mouse & Keyboard	Logitech Cordless Navigator Duo SE	$55
Speakers	Creative Labs Inspire 7.1 T7700	$115
Operating System	Windows XP Home	$90
PSU	470W Enermax Noisetaker	$69**
Miscellaneous	Logisys Cold Cathode Light	$10
Total		**$2,497**

* Equipment previously purchased.
** After $15 mail-in rebate.



The chassis includes removeable drive cages that let you quickly add or remove drives—handy in case you decide to upgrade down the road. Thumbscrews secure the floppy and hard drive cages.

Wi-Fi@Home card. The card supports the popular 802.11g standard, and the antenna attaches via a long cable, which means you can move the antenna to find the strongest signal. We think this is one of the best motherboard extras we've seen.

The mobo has four memory slots, two of which are blue (the other two are black). The board includes dual-channel technology, which means that each set of two slots transfers data via a separate channel instead of sharing one. We grabbed our Mushkin DIMMs by their purple heatspreaders and plugged them into the two blue sockets.

We'd done all we could do outside of the chassis, so we slid the mobo tray back into the PC and connected the front-panel cables and the mobo's extra FireWire port, which attaches to the board's internal connectors and fills a PCI bay. We also added our cold-cathode light, which attaches to the inside of the case via Velcro stickers. We were pleased to see that the light cast a faint blue glow on the interior.

Next, we connected the hard drives to the mobo with two of the board's four SATA cables. We also attached the floppy drive's and DVD±RW drive's ribbon cables. Finally, we unleashed the PSU's mess of power cables. We used the standard 4-pin connectors to power the fans, video card, and optical drive and then plugged a smaller connector into the floppy drive. We connected the smallest connector (which had a purple and white cable) to the board's power fan connector. Although the PSU flooded the case with cables, we didn't have much trouble tucking most of them into various nooks and crannies. If you have trouble hiding a particular wire, you can secure it to a nearby piece of metal with a plastic cable tie.

We set up our speaker system, attached the monitor, and pressed the power button. As with our midrange system, the computer responded by not starting. And as with the other machine, we traced the problem to the power switch cable. However, the problem was our fault this time. When we plugged the cable into the mobo connector, we missed by one pin. Whoops. We quickly attached the cable to the right pins and then powered on the computer.

System Notes	
Outstanding Features:	The Lian-Li gives our system a crisp, clean appearance and will let us easily upgrade in the future.
Weak Link:	We didn't have enough cash to spring for a 19-inch flat-panel monitor, which would have really spiced up our system. Of course, we would have been happy with a functioning monitor, which our dead CRT didn't provide.
Dimensions (Tower):	450 x 210 x 490mm
Weight (Tower Only):	27.5 lbs
Benchmarks	
We ran PCMark04 (version 1.2.0, with Windows Media Player 9) and 3DMark03 (build 340, with DirectX 9.0b) at default settings.	
PCMark04 System	4702
CPU	4448
Memory	4825
Graphics	4643
Hard Drive	4537
3DMark03	5699

We jumped into the BIOS (by pressing DELETE at startup) and tabbed over to the Power category. We scrolled down to Hardware Monitor, which let us quickly assess our computer's temperature and fan speeds. We noticed that the PSU fan was running at a mere 811rpm, so we turned the knob at the back of the PSU until the speed jumped to 1,467rpm. Even then, our PSU was nearly silent. Although we weren't focusing on noise control, we built an extremely quiet system.

Before we installed Windows XP, we used a different computer to create our PC's SATA driver disk. WinXP doesn't have the appropriate drivers for SATA hard drives, which means you'll need to install them via a floppy diskette at the beginning of the Windows installation. Unfortunately, the mobo's feature-laden package didn't include a driver disk. We grabbed an old floppy and then popped it and the mobo's driver CD into the other computer. Next, we double-clicked My Computer, right-clicked the CD-ROM drive, and then selected Explore from the context menu. We opened Drivers, VIARAID, 6420RAID, and DriverDisk and then double-clicked Makedisk.exe, which installed the drivers on our floppy disk.

Next, we put the WinXP installation CD into our PC, rebooted, and then watched the bottom of the screen for the message that instructed us to press F6. We pressed F6, waited while Windows installed a few more files, and then pressed the *S* key at the appropriate screen to pull the drivers from the floppy. Once Windows extracted the drivers, it continued with the installation.

Testing

We expected our high-end system to pummel the midrange PC's benchmark scores, but our system just barely pulled ahead at 5699 3DMarks (to the lesser PC's 5562). However, our computer managed a stronger lead when it posted an overall PCMark04 score of 4702, which topped the midrange PC's score by more than 1,000 points. Our PC's speakers roared to life when we popped a DVD into our machine. The 92W system creates much richer sound than its 5.1 counterpart. We expected better performance from the more powerful system, but we were surprised nonetheless when we heard the 7.1 system. We also tested the wireless adapter, which located our network without trouble.

Final Remarks

Although our system's benchmark scores are not as outrageous as we had hoped they would be, we really like this system. It produces excellent audio and video, and it has an included wireless adapter. With many home- and small-office networks going wireless, we suspect this feature will eventually be as common as integrated Ethernet ports.

Of course, one of the most important measures of a system's worth is its upgradeability. Our system's guts will march slowly toward obsoleteness, but the chassis, keyboard, mouse, and speaker system will last for many years. (We can't say the same for the monitor.) We're particularly pleased with the chassis, which makes upgrading a pleasure. For now, we'll enjoy the system for what it is today: a thing of beauty. RS

by Joshua Gulick

Best High-End Intel PC Under $2,500

Performance & Fun For The Family

Build #6 Skill Level: 1 2 3 4 5 ***Journeyman***

As we've seen, you can build a decent system for less than $1,500. Just imagine, then, what you can get if you have an extra $1,000 burning a hole in your pocket. We increased our budget to $2,500 and set out to build the best Intel system we could for the money.

Goal

Once again, our focus here is on fun and flexibility. Sure, a gaming system is nice, but we want something the whole family can use to accomplish anything from video editing to, well, playing video games. Our increased budget allowed us to cut fewer corners and pick up higher quality parts to improve our overall performance.

Background

Obviously, the first thing we wanted to spend our extra money on was a processor. When we built our midrange system (see page 20), we settled for a 3GHz Pentium 4 processor that cost a little more than $200. We doubled our processor budget this time and picked up a 3.4GHz Pentium 4. Once again, we opted for a Northwood-based P4 as they use less energy, run cooler, and outperform newer Prescott chips clock for clock. Until Prescott chips get faster, we'll stick with Northwood.

We ditched the stock Intel aluminum heatsink and opted for a Thermaltake P4 Spark 7+. The Spark 7+ set us back about $24, but it looks sharper than Intel's stock heatsink and its copper design is a better heat conductor than aluminum. The Spark 7+ also includes a better fan with variable speed control (from 1,300rpm to more than 6,000rpm).

To show off our processor, we opted for a high-end ABIT IC7-MAX3 motherboard and added two 512MB sticks of Kingston HyperX PC3200 DDR SDRAM. The IC7-MAX3 uses Intel's 875P chipset, which supports PAT (Performance Acceleration Technology). PAT uses aggressive memory timings to decrease memory latency and improve performance when paired with PC3200 DDR SDRAM.

Truth be told, PAT doesn't usually provide significant performance benefits, but there is more to this board than an Intel 875P. The IC7-MAX3 also supports up to six SATA drives. The Intel ICH5R on the southbridge supports two SATA drives in an optional RAID 0 or 1 configuration. An SiL 3114 SATA RAID controller supports four additional SATA drives in various RAID configurations.

In addition to supporting RAID, the IC7-MAX3 also includes Gigabit Ethernet, which will make sending large files around your home network much, much easier. The motherboard also supports 5.1-channel surround sound.

For the video card, we opted for an ATI All-In-Wonder Radeon 9800. The All-In-Wonder cards let you capture audio and video from a VCR, camcorder, or television input. Included software lets you watch TV on your computer and record your favorite shows to your hard drive.

The Radeon 9800 graphics chip used in this card is a significant improvement over the 9600 we used in the previous midrange Intel system. As you'll see, the 9800 delivered much better PCMark04 and 3DMark03 scores.

Our midrange Intel system used a rather expensive Cooler Master Wave Master case. This time around, we went with a

System Notes	
Operating System	Windows XP Home
Processor	3.4C GHz Pentium 4 (Northwood)
RAM	1GB PC3200 DDR SDRAM
Bus Speed	800MHz
Hard Drive	160GB SATA RAID 0 Array
Optical Drive	Plextor 708A-BPS/BL
Connectivity	Gigabit Ethernet
Video Card	ATI All-In-Wonder Radeon 9800
Video RAM	128MB
Monitor	21-inch ViewSonic PerfectFlat CRT
Sound Card/Speakers	5.1-channel Surround Sound
Chassis Size (inches)	20.6 x 8.1 x 18.6
Weight (lbs)	26.32
Benchmarks:	
3DMark03	5991
PCMark04	5214
CPU Score	5011
Memory Score	4964
Graphics Score	4145
HDD Score	6821

slightly less expensive Antec Performance Plus1080AMG case. The case includes an Antec 430W power supply. While not quite as nice as the Wave Master we used earlier, the Antec case is still solid and includes a number of nice features, such as removable 3.5-inch drive bays and toolless 5.25-inch drive bays. The $119 price let us splurge a little more on our other components.

As with our midrange model, we wanted to include a DVD burner. With a larger budget, we purchased a higher quality Plextor drive. We also included two 80GB SATA hard drives that we'll combine into a RAID 0 array to improve hard drive performance.

With digital cameras becoming more popular, we find more and more uses for small removable media. We picked up an Addonics IDE DigiDrive to handle our removable media. The drive can handle SD, MMC, SmartMedia, CompactFlash, MicroDrive, Memory Stick, and Memory Stick Pro formats and fits into a standard 3.5-inch drive. We also installed a floppy drive. Yes, we know no one uses floppies anymore, but just try to install Windows XP Home on a SATA RAID 0 system without a floppy drive.

To accompany our tower, we picked up a massive 22-inch CRT monitor for $429. While the CRT takes up more space than a flat panel, it'll be a little better for gaming as CRTs deliver faster refresh times. Plus, we'll have a larger viewable display than we could get from an LCD at this price. We also added a Logitech MX500 optical mouse and a Kingston keyboard.

The Build

Considering the better components we were able to afford, we were looking forward to assembling this system more than we were the midrange system. We opened up the Antec case and removed the thumbscrews securing the left side panel. To remove the panel, we simply lifted the latch near the rear of the panel and swung the side panel outward. We were surprised to find a thick set of instructions with the case (by far the best set of case instructions we've seen). We removed the additional hardware components (screws, power cords, etc).

We grabbed the I/O plate included with our ABIT board and replaced the I/O plate in the back of the system. We then lowered the motherboard into place and noted the proper positions to mount standoffs. After removing the motherboard, we screwed the standoffs into the motherboard and secured the motherboard to the standoffs using the included screws.

With the motherboard in place, we dropped the processor into the ZIF socket, applied a small amount of thermal paste to the center of the metal heat spreader, and placed the heatsink on top of the processor. Using the two included clips, we secured the heatsink and attached the yellow wire to the fan header on the motherboard. The fan draws power from the power supply rather than the motherboard header, but connecting the yellow wire will let the motherboard's hardware monitor detect and report the fan's rpms. We installed the memory modules into the blue memory slots.

With the motherboard, processor, and memory all in place, it was time to move on and wire the motherboard to the case. We mounted the USB and FireWire bracket included with our motherboard to the bottom expansion slot and connected the blue plug to one of the USB headers on the motherboard. We connected the red plug to one of the FireWire headers on the board. We then connected the front USB and FireWire ports to the remaining USB and FireWire headers.

Our next step was to wire the power switch, reset switch, HDD LED, and Power LED to the motherboard. We used the included motherboard manual to figure out which pins to connect which wires to. Our case includes two additional LEDs, and the motherboard has headers for a suspend LED. We wired the leads marked I to the Suspend LED headers on the motherboard.

Next, it was time to add the drives. Before we could install the Plextor DVD burner, we needed to remove the drive bay covers. We used a thin screwdriver to push the outer plastic case cover off. With the plastic cover removed, we could rotate the metal cover inside until it broke free from the case. Our heatsink includes a fan controller that we'll mount to an additional 5.25-inch drive

Our case has a number of nice features including toolless 5.25-inch drive bays and removable 3.5-inch drive bays.

bay, so we needed to prepare two 5.25-inch bays.

We used four screws to secure two rails to the DVD burner with the tabs on the rails facing the front of the drive and angled away from the drive. We then slid the drive into one of the vacated drive bays until it latched into place. Originally, the drive wasn't quite flush with the case, so we pushed the tabs together and pulled the drive out. We remounted the rails farther up the drive, and it fit perfectly into its bay.

You can mount the fan controller in a similar manner. The controller doesn't quite have the length of a DVD burner, so you'll need to secure the drive rails to the two screw holes on either side of the fan controller. Slide the controller into place until it latches.

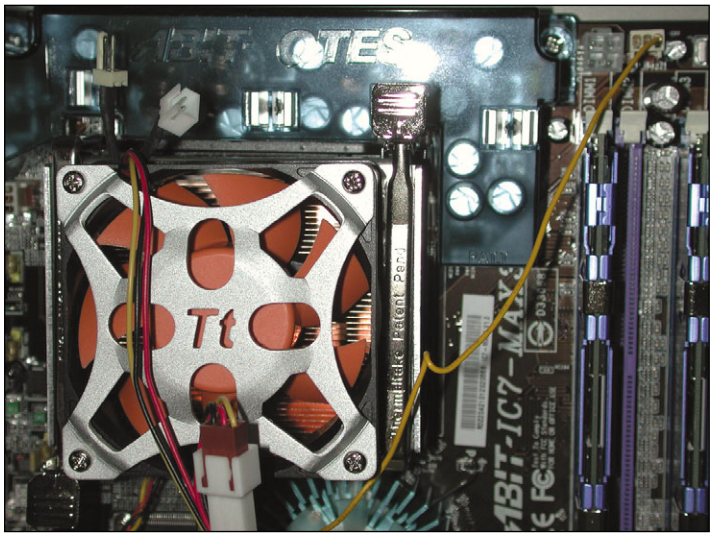
We needed to remove plastic and metal covers from the two 3.5-inch external drive bays, as well. We then removed the upper 3.5-inch drive cage by sliding the release lever toward the back of the case and pulling the cage out. We mounted both the Addonics card reader and our floppy drive in the top two 3.5-inch drive bays, reinserted the cage, and latched it into place. Next we removed the bottom drive cage and mounted our two 80GB SATA hard drives.

We removed the second PCI expansion slot cover from the top to make room for our ATI All-In-Wonder card. To remove the expansion slot cover, we simply loosened the screw holding it in place and pulled the cover off. We slid our ATI video card into place and pressed it firmly into its AGP slot. In order to get sound from our TV signal, we connected the A/V output cable to the back of our All-In-Wonder card and connected the audio output to the line-in jack on our motherboard.

Next, we began connecting devices to the motherboard and PSU. We plugged the DVD burner into the second IDE channel (located above the primary IDE connector) and plugged an IDE ribbon cable into the primary IDE connector at the bottom of the motherboard. After we install Windows XP, we'll connect the other end to the Addonics card reader we installed.

We connected both our SATA hard drives to the two SATA ports near the Intel ICH5R southbridge. These ports are controlled by the ICH5R and stand separate from the four SiL 3114-controlled SATA ports lining the bottom of the motherboard. We connected the other end of each SATA cable to our two drives.

Finally, we removed the rubber band that kept all the power supply cables out of our way. We connected the ATX power supply and the 12-volt connector to the motherboard. We then connected power cables to the two hard drives, DVD drive, floppy drive, video card, and our rear case fans using the appropriate connectors.



We like pretty pictures of cool PC components. Anyway, after installing a small amount of thermal paste, we mounted our copper heatsink and attached the yellow wire to the CPU fan header on the motherboard.

We closed up the system after connecting the side fan to the power supply and connected our monitor, keyboard, mouse, and Ethernet cable. We plugged our system and monitor into an outlet and booted up for the first time.

RAID configuration. We had two identical hard drives and a motherboard that supports SATA RAID. We weren't going to let this opportunity go. Configuring a RAID array is rather easy once you've properly configured the BIOS.

We turned on the power and pressed DELETE to enter our BIOS setup utility. We selected Standard CMOS Features from the main menu. All we needed to do here was set the proper date and time. Once set, we pressed ESC to return to the main menu.

In order to get our SATA RAID working properly, we needed to adjust a few settings in Advanced BIOS Features. We selected Hard Disk Boot Priority and pressed ENTER. We selected Bootable Add-In Device and pressed PAGE UP to move it to the top of the list. We pressed ESC to return to the previous menu, selected Bootable Add-In Device, and chose OnChip SATA RAID. We then made sure we had CDROM selected for our First Boot Device, Hard Disk for our Second Boot Device, and Floppy for our Third Boot Device. We then pressed ESC to return to the main menu.

We used the cursor keys to select Integrated Peripherals and selected OnChip IDE Device. We selected OnChip SATA Mode near the bottom, pressed ENTER, and selected RAID. We then made sure SATA Boot ROM was Enabled. We pressed ESC twice to return to the main menu, selected Save & Exit, and let the system reboot with the new settings.

As the system boots, it'll prompt you to press CTRL-I to configure your RAID devices. Select Create RAID Volume and follow directions. Make sure you select RAID 0 Striping rather than RAID 1 Mirroring. Insert your Windows XP installation disc and reboot the system.

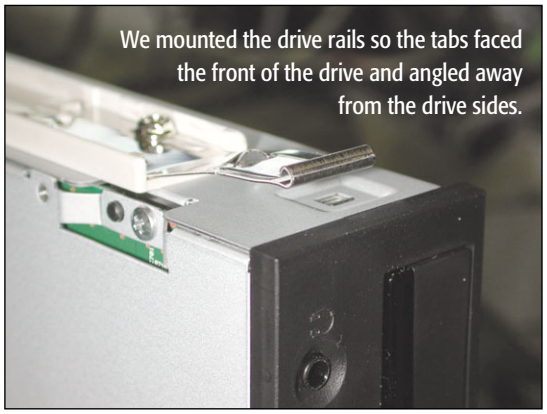
Windows XP. The Windows XP installation process is fairly straightforward, but there are a few quirks thanks to our SATA RAID configuration. When you first see the blue Windows Install screen, you'll need to press F6 to install a third-party driver (in this case the SATA RAID

drivers). The installer will continue copying some files before prompting you to load your third-party drivers from a floppy diskette.

We pressed S to install a new driver and inserted the diskette included with our motherboard when prompted. A list of four drivers appeared, but because we weren't using the SiL 3114 SATA RAID controller, we only needed to select Intel 82801 SATA RAID Controller For Windows XP & 2000. After the installer copied the file from the diskette, we pressed ENTER to proceed with the installation.

Troubleshooting. The above steps have been condensed to make them easier to follow, but in reality this system proved very difficult to assemble and configure. The instructions outlined above are laid out to help you avoid similar problems.

We ran into two big problems building this system. The first was a power problem. Originally, we wanted to include a Sound Blaster Audigy 2 ZS sound card and a 7.1-channel surround-sound speaker system. Unfortunately, our 430W power supply had trouble keeping up with demand, leading to system instability and odd error reports during WinXP installation. At one point, the WinXP installer insisted that the SATA RAID drivers were corrupted. Removing the Audigy 2 ZS cured our problems, allowing us to install WinXP without any problem and creating a more stable overall system.



We mounted the drive rails so the tabs faced the front of the drive and angled away from the drive sides.

The second problem stemmed from our card reader. Originally, we set the card reader to be a slave on the primary IDE channel with our DVD burner. Theo-retically, this shouldn't be a problem, but in reality the two devices don't share an IDE channel very well. We reset the card reader to be a master device and connected it to its own IDE channel.

During one of our many OS reinstalls, we discovered that the card reader had stolen the C: drive designation when on its own IDE channel. Our hard drive became drive E:. This wouldn't be a huge problem except that some software expects a hard drive to be present on drive C:. The GuidePlus+ software included with our ATI All-In-Wonder 9800PRO card lets you set your computer to record your favorite television shows. GuidePlus+ must install its database to drive C:. To correct this error, we disconnected the IDE cable and reinstalled Windows. Once Windows was reinstalled, we could connect our card reader and install its drvers. Windows kept the hard drive assigned to drive C:.

Post install. With our stability problems behind us, we installed the drivers and software included with our hardware. WinXP can provide drivers for most Ethernet controllers, but the Gigabit controller on the IC7-MAX3 will need the Intel drivers on the CD-ROM included with the motherboard. You'll also want to install the Intel Application Accelerator RAID Edition software and motherboard drivers.

Parts List

Component	Model	Price
Case	Antec Performance Plus1080AMG	$119
Power Supply	Antec 430W TruePower (Included with case)	
Motherboard	ABIT IC7-G Max3 (875P)	$177
Processor	3.4C GHz P4 (Northwood)	$415
Memory	Kingston HyperX 512MB (x2)	$264
Hard Drive	Hitachi HDS722580VLSA80 (80GB x2)	$148
Video Card	ATI All-In-Wonder 9800PRO	$334
Sound Card	Integrated	
Network Card	Integrated	
DVD Writer	Plextor 708A-BPS/BL (OEM)	$139
Diskette	Mitsumi 1.44MB Floppy (silver)	$11
Card Reader	Addonics 7-in-1 Digi Drive	$54
Monitor	ViewSonic PerfectFlat 21-inch CRT	$429
Speakers	Cintre RW-6580D	$36
Mouse	Logitech MX500 Optical Mouse	$39
Keyboard	Kingston Keyboard-in-a-box (USB)	$25
OS	Windows XP Home SP1a OEM	$90
Heatsink	Thermaltake P4 Spark 7+	$24
Total		**$2,303**

Testing

With everything installed and configured, we could finally have some fun with our new high-end system. We started off by running 3DMark03 to gauge our system's gaming performance and PCMark04 to rate the relative strengths of our individual components. The extra $1,000 bought us a significant improvement in performance.

Our overall PCMark04 score increased from 4367 to 5214. The CPU score itself increased nearly 500 points to 5011. The most impressive increase, however, was the PCMark04 Graphics score, which rose from an unflattering 1849 to 4145. Next to our Graphics score, the most impressive score was our HDD score, which rose from a 4573 to an impressive 6821 thanks to our RAID 0 configuration. The Memory score was also up significantly to 4964. As these numbers may lead you to expect, our 3DMark03 score also increased dramatically, moving from a 2555 to a very respectable 5991.

Final Remarks

The system handled DVD playback without any problems and the sound was decent, although we were disappointed we couldn't use our Sound Blaster Audigy 2 ZS card. In the end, we liked this system's flexibility more than anything else. Whether you want to play games, record television shows (and burn them to DVD), or simply get some work done, this system can handle just about anything you throw its way. RS

by Chad Denton

Best General Business System Under $1,500

Computer For Anybody's Business

Build #7 Skill Level: 1 2 **3** 4 5 ***Journeyman***

Building a general business computer with a limited budget is an exercise in absolute practicality. We weighed the costs and functions of every component we chose in order to get the biggest bang for our buck, all the while assuming that the money we put into this system would translate into enough productivity to eventually pay for the system.

Goal

The objective was to build a computer that was applicable to any business atmosphere. If you're thinking of starting your own business or already have your own business and just want more control, this system will help you rein in your finances and track your transactions. We had $1,500 to work with, of which we spent a healthy amount on software. We also set aside a portion of our budget for an all-in-one print, fax, and copy machine. Our mouse, keyboard, monitor, and case were low on our list of priority hardware.

Background

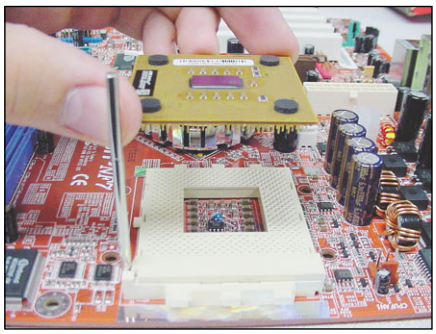
Our desire to keep this machine quick and affordable led us to the 1.9GHz Athlon XP 2600+ CPU. The motherboard we chose had to have RAID 1 capabilities to provide fail-safe data security for our sensitive business and financial data. The motherboard for our business system also had to have plenty of peripheral connections and a dual-channel memory controller and needed to fit into an affordable price range. The ABIT NF7-S with the nForce2 chipset met our requirements and came with plenty of extra features. A 1GB dual kit of Kingston PC 3200 memory was more than enough to keep us satisfied, but 512MB of RAM would be a cheaper yet effective alternative. Buying PC2600 memory at 333MHz also would save you some money, especially considering the Athlon XP's 333MHz FSB. The dual-DDR kit in conjunction with the NF7-S's dual-channel memory controller should provide a decent memory boost. Graphics weren't a priority, so we went for the low-priced NVIDIA GeForce FX5200 with 128MB of dedicated video memory. You may want to choose a motherboard with integrated graphics, but we prefer to have the added input/output ports that a standalone video card offers. We already had an FX5200 Ultra on hand, which features 650MHz DDR memory, so we used it. The non-Ultra FX5200, which has 400MHz DDR memory, will save you enough money to be worthwhile.

We wanted an attractive case with some side vents to allow for extra ventilation, front-panel USB and audio ports, and an onboard PSU. Our TASK WHOIS mid-tower case with 400-watt PSU was less than $30, but we didn't want to take any risks and left room in our budget for a new PSU (in case the included PSU failed). Our system won't be taxing the limits of the power supply, so we should be OK. The case includes four external 5.25-inch drive bays and two external 3.5-inch drive bays, as well as four internal bays we can use for hard drives. This case doesn't exactly have it all, especially in the way of cooling options, so we bought an 80mm Thermaltake high-performance case fan to provide some much needed exhaust. Our VGA monitor is a recertified IBM G78, which is a 17-inch CRT. We bought a generic keyboard and mouse combo for less than $10. We found a set of Altec Lansing ACS5 stereo speakers among our in-house hardware but saw an identical set selling on eBay for $5.

Our straight-laced case, prior to the build.

We bought an all-in-one optical drive, Plextor's PX-708A/SW, which will let us read and write multiple formats of CDs and DVDs. We also included a 3.5-inch floppy drive. We bought two identical Samsung 80GB Serial ATA hard drives, which we plan to use with the NF7's RAID controller.

One of the main features of our general business machine is the all-in-one printer. The Brother MFC-4820C copies, faxes, prints, and scans. The MFC-4820C also includes a handset, which eliminates the need for a standalone telephone. We also bought a USB cable to connect the printer to our computer.



The gold triangle goes closest to the socket arm hinge.

We chose Windows XP Home as our OS and bought Microsoft Office Small Business Edition 2003. We also bought Quicken 2004 Premier Home and Business Edition to quickly and easily coordinate transactions and expenses with financial institutions.

The Build

First, we prepped our case by removing both side panels and dislodging the input/output panel plate to make room for the plate that came with our motherboard. Before touching any of our components, we made sure to diffuse static electricity by touching a grounded piece of metal. Next, we set our motherboard on a sheet of foam and familiarized ourselves with the various parts while flipping through the manual. With a basic idea of the locations of various leads, ports, slots and plugs, we turned our attention to the CPU.

The Athlon XP 2600+ we purchased came with the stock heatsink and fan assembly, as well as instructions for installing both. We lifted the NF7's socket-locking arm to a 90-degree position. The Athlon XP 2600+ processor has a small, gold triangle at one corner that goes closest to the locking arm's hinge. The CPU only fits into the socket one way, so force wasn't necessary. With the pins lined up properly, we slid the CPU in place and lowered the socket-locking arm to the locked position.

The heatsink comes with a clear plastic lid over a patch of thermal paste. The thermal paste must be fully intact to transfer heat properly. The thermal paste patch looked OK, so we removed the lid and lined up the heatsink over the processor. The heatsink secures to the socket with an asymmetrical V-shaped clip with three square holes on each side. We clipped the shorter side of the clip to the locking lugs built onto the socket. The opposite side of the clip has a green plastic tab with a wide surface. We pressed on this tab and with a little difficulty managed to latch the three holes over the three locking lugs on the socket. Undue force applied directly to the heatsink fan can damage it, so make sure to only apply pressure to the clip. Finally, we connected the CPU fan to the plug on the motherboard labeled CPU FAN.

The DIMM slots of our NF7-S support dual-channel memory. We checked the manual for the best configuration and installed the two 512MB sticks of memory in the purple slots labeled DIMM 1 and DIMM 2. With the ejector tabs open, we pushed the module into place, one edge at a time, making sure to line up the notch in the module with the notch in the slot. We pushed the module in until the tabs locked them into place. We followed the same procedure for the second module using the second purple slot, labeled DIMM 2.

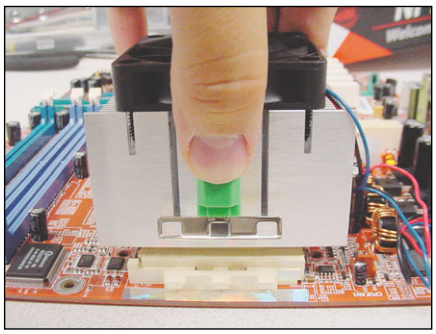
Next, we installed the motherboard to the mounting plate. We started by positioning the motherboard inside the case and lining up the screw holes for both the motherboard and mounting plate. We marked the holes with a pencil on the back of the mounting plate so we knew where to insert spacers and standoffs. We removed the motherboard and screwed in the plastic spacers and metal standoffs. Next, we put the motherboard back into the case and used the spacers to hold the board while we screwed it to the standoffs.

With the motherboard in place, we went about the task of connecting our front-panel USB and audio ports. We had to remove two jumpers from the audio leads in order to access them. The motherboard manual details the proper leads for each connector. The connectors from our case were clearly labeled, as well. We then connected the power switch, reset switch, IDE and power LEDs, and internal speaker plugs to the system panel connector leads. The manual for the NF7-S provides a detailed diagram with descriptions of every plug and lead. We made sure to keep the plug labels facing outward. We then supplied power to the motherboard with both the 4-pin auxiliary connector and 20-pin ATX power connector, making sure to match the plastic clip of the connector with the lug on the motherboard connector.

Next, we mounted the 80mm Thermaltake fan just below the PSU to help cool our components. We checked the horizontal arrow on the side of the fan housing and mounted it so that the arrow

Parts List

Component	Model	Price
Case	TASK WHOIS Mid-Tower Case (400W PSU included)	$27
Monitor	IBM G78 1,280x1,024 17-inch Flat Black Monitor (Recertified)	$90
Keyboard	Generic Keyboard	$4
Mouse	Generic Mouse	$5
Mainboard	ABIT NF7-S	$83
CPU	AMD Athlon XP 2600+, 512K Cache (fan and heatsink included)	$90
RAM	Kingston ValueRAM Dual Channel Kit 1G (512MBx2) DDR PC-3200	$87
Hard Drive	SAMSUNG 80GB SATA Hard Drive (x2)	$158
Optical Drive	Plextor 8X DVD±RW Drive	$141
Floppy Drive	Mitsumi 1.44MB 3.5-inch FDD	$13
Video Card	NVIDIA GeForce FX5200	$60
OS	Windows XP Home full OEM version	$64
Software	Quicken 2004 Premier Home and Business	$58
	Microsoft Office Small Business Edition 2003	$347
Case Fan	Thermaltake 80mm, TT8025A-2B	$5
Printer	Brother MFC-4820C Multifunction Printer	$231
Cables	3ft AM/ BM USB 2.0 Beige Cable	$2
Speakers	Altec Lansing ACS5 Stereo Speakers	$5
Total		**$1,470**



Our heatsink took some effort to install.

pointed toward the outside of the case. This arrow indicates the airflow direction when the fan is spinning.

The video card went in next. We started by removing the metal box that revealed the expansion slot screws. We had to bend and break off the metal tab that lined up with our AGP slot. After we made sure the connector lock on the AGP slot was open, we slid the NVIDIA GeForce FX5200 into the AGP slot until the connector lock engaged. Next, we screwed the bracket to our case and powered our video card with a 4-pin Molex plug. We then removed the bottom expansion slot tab to make room for the auxiliary USB and FireWire ports. We screwed the bracket into the slot and then connected the red plugs to the red FireWire leads on the motherboard, labeled IEEE1 and IEEE2. We then connected the blue USB plug into the remaining USB lead labeled USB1.

Time-saver

Our cheapo power supply didn't offer SATA power plugs, nor did we have SATA drives that supported the standard Molex power connector. As a result, we had to find a SATA power adapter to connect our SATA drives. Our motherboard also came with only one SATA cable, which had us scrambling for a second cable to complete our RAID configuration. We also bought a USB cable for our Brother MFC-4820C. Always note the kind of cable your printer requires to connect to your computer because the proper cable is often not included. If you pick these up ahead of time, you will save yourself some time and frustration. ▲

Next, we installed our external drives. We started by popping out the top 5.25-inch drive bay cover and the top 3.5-inch drive bay cover. We took the 3.5-inch floppy drive and 5.25-inch optical drive and slid them into the bays from the front of the case, securing each drive with four screws. We then powered each drive with plugs from the power supply. We connected the optical drive to the motherboard using the included ribbon cable. The black plug designates the master drive, so we plugged it into the optical drive. We then attached the blue connector to the motherboard IDE1 plug. The floppy ribbon cable connects to the FDC1 plug on the motherboard, just to the right of the DIMM slots. Both of the ribbon cables included with the motherboard were notched so they only fit into the motherboard plugs one way.

Our internal hard drives went in next. We used the bottom bay and the third bay from the bottom to give our two hard drives some breathing room. We secured the two drives with screws and connected the SATA cables to the ports labeled SATA1 and SATA2. We then used a SATA power adapter to convert a 4-pin Molex plug from our PSU into two SATA power plugs.

Finally we connected our peripherals (speakers, monitor, mouse, and keyboard) and prepped our system for its inaugural boot.

Testing

After doing a last-minute check of every wire, lead, and power connection, we turned on the monitor and plugged in the power supply. We switched on the power supply and noted that the motherboard's red power LED lit, which indicated that our board was getting power.

We pressed the power button and immediately noticed that the CPU and case fans were operating normally. When prompted to press DELETE to enter the BIOS Configuration Utility, we did and proceeded to access the Advanced BIOS Features item from the BIOS menu options. We then set the date and time and verified that the boot sequence was listed as Floppy, CD-ROM, and HDD 0. We pressed F10 as indicated to save and exit the BIOS, at which point the system rebooted. This time we waited until we were prompted to press CTRL-S to access the RAID Configuration Utility, which we did. Because we were recycling the hard drives from a previous system, we performed a low-level format for each drive to give us a clean slate. We then selected the option to Create RAID Set.

We chose to use a RAID 1 configuration (mirroring) because of the increased data security that mirroring provides (refer to "RAID 1 Under $1000" on page 96 for more information on RAID). We selected Manual Configuration and then chose our source and destinations drives. We selected Yes when prompted for Disk Copy. When the RAID set was built, we opened our CD-ROM drive and inserted our WinXP Home CD. We then pressed CTRL-E to exit the RAID Configuration utility, which rebooted the machine. As our system ran the POST, we partially inserted the 3.5-inch floppy SATA drivers disk (found among the motherboard accessories). At the blue Welcome To Setup screen, we pressed ENTER to set up WinXP. We then pressed F6 when prompted to install the Serial ATA

System Notes	
Price	Under $1,500
Operating System	Windows XP Home
Processor	AMD 1.9GHz Athlon XP 2600+
RAM	1GB PC3200 DDR SDRAM
Bus Speed	333MHz
Hard Drive	80GB (RAID 1)
Optical Drive	Plextor PX708A 8X DVD+R, 4X DVD-R, 4X DVD+RW, 2X DVD-RW, 12X DVD-ROM, 40X/24X/40X CD-RW
Connectivity	10/100Mbps Ethernet
Peripheral Connectivity	2 FireWire; 6 USB 2.0
Video Card	NVIDIA GeForce FX5200
Video RAM	128MB
Monitor	IBM G78 17-inch VGA CRT (Recertified)
Sound Card	Integrated audio
Speakers	Altec Lansing ACS5 stereo speakers
Chassis Type	Mid Tower
System Use	General Business Applications

drivers. After a few more items loaded, we pressed S when asked if we had a device support disk. The next screen prompted us to insert the disk and press ENTER. We chose the Silicone Image Sil 3112 SATA RAID Controller For WinXP as the SCSI adapter to install and pressed ENTER.

Back at the Windows Setup screen, we noted that the install recognized the mass storage devices attached to our RAID controller, so we pressed ENTER to continue with the setup. Next, we chose the unpartitioned drive upon which to install WinXP. Notice that the mirrored RAID set appears as half of the sum total of both drives' capacities. This is because mirrored drives contain the same information (hence, the term "mirrored"), which ensures that your data is kept intact even if one of your hard drives fails. Once the new partition had been created, we chose the quick NTFS formatting option. Because we had previously formatted the drives in the BIOS, there was no need to spend the extra time to fully reformat them.

Setup continued to copy files to the Windows installation folders, and then the system rebooted. When prompted, we pressed F to format the NTFS volume for the install. Once the formatting was finished, we loaded WinXP and proceeded to load the drivers for our onboard sound, video card, and multifunction printer.

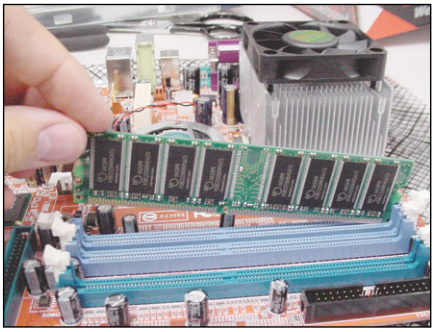
The copy of WinXP Home that we installed included Service Pack 1a, which is important because it provides support for USB 2.0, which will boost our printer and peripheral communication speeds. If your copy of WinXP doesn't include SP1, we suggest you visit www.microsoft.com to download the service pack.

With Windows up and running, we installed Microsoft Office Small Business Edition 2003 and Quicken 2004 Premier Home and Business Edition. In Microsoft Excel, we created a spreadsheet that listed the cost of each part that makes up our General business machine. Then, using Excel's chart wizard, we created a pie chart that shows us our $1,500 budget and what percent of that budget we spent on each aspect of the system.

Final Remarks

For anyone with the desire to build a business, building a computer tailored to manage that business seems like an elementary first step. This system can also serve as an upgrade of an older business machine by providing the fail-safe data security of RAID 1, as well as the ability to scan important paper documents. Microsoft Office Small Business Edition 2003 delivers the tools you'll need to produce spreadsheets, presentations, databases, sales and marketing materials, and charts and graphs. The included Business Contact Manager also helps you manage your customers and business partners. Quicken 2004 Premier Home and Business Edition lets you quickly calculate your net worth, track investments, simplify taxes, manage transactions, and even balance your checkbook, all with color-coded graphs and charts. RS

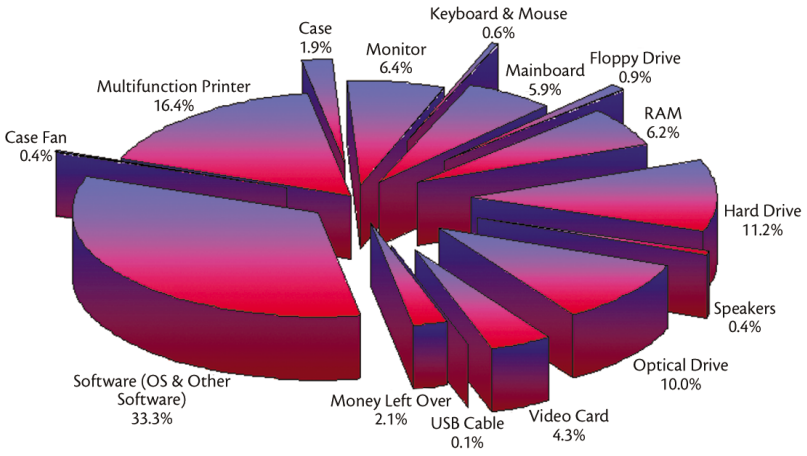
by Andrew Leibman



We used DIMM slots 1 and 2 for the RAM.

Business Computer Budget

The Percentage Of Our $1,500 Budget Spent On Each Component



Watch Out

Getting our RAID drivers installed required a little trial and error and a lot of patience. It took several reboots to discover that we needed to load the SCSI drivers for our RAID controller before Windows Setup would proceed. In the interim, however, we loaded the Fail-Safe Defaults in the BIOS menu, which counted the memory until we told it to stop. Next, we tried resetting the CMOS as the motherboard manual suggests and upon reboot got the error "CPU is unworkable or has been changed – Please recheck CPU SOFT MENU." Before panicking, we reset our BIOS to Optimized defaults, which eliminated the error on subsequent boots.

At one point, we changed the boot sequence, after which the system booted until the "Verifying DMI pool data" phrase appeared. Then the screen would go blank and reboot to the same point and continue this repeatedly. A quick switch to the default BIOS settings fixed the problem, which reminded us that we changed the boot sequence. This point illustrates how important it is to note any changes you make to the BIOS while troubleshooting a problem. ▲

Best Communication System For Under $1,000

Stay In Touch Electronically

Build #8 Skill Level: 1 2 **3** 4 5 ***Journeyman***

Computers provide the ultimate in flexibility. They can certainly be tools to make you more productive, they can entertain, and they can also help us stay in touch with friends and family around the world. Sometimes we tend to focus on computers as productivity tools or entertainment providers, and we forget some of the more mundane ways computers can help us communicate with others. In this article, we'll focus exclusively on a communications system.

Goal

With a budget of $1,000, we wanted to build a system that could do more than email and IM. Our goal was to build a single system that could handle various forms of communication. We wanted a system that could send and receive faxes and store voicemail, as well as handle our email and IM needs. We don't need to spend a lot of money on performance to accomplish these goals; we just need to make sure we have the right parts for the system.

Background

We started by picking out a modest processor. We went with AMD's Athlon XP 2600+ with a 333MHz FSB. We were able to find one for $85. The Athlon XP is getting old, but a low-end Athlon 64 would've cost us an extra $70, plus we would've needed to spend an extra $30 for a Socket 754 motherboard and even more on PC3200 DDR SDRAM.

We complemented our Athlon XP 2600+ with an ASUS A7V600-X motherboard. The A7V600-X uses a VIA KT600 chipset that supports FSB speeds as high as 400MHz. The motherboard also supports two SATA hard drives and up to 3GB of PC3200 DDR SDRAM. A 10/100 Ethernet controller and a 5.1-channel AC'97 audio codec are also integrated onto the motherboard.

Considering our processor uses a 333MHz FSB, PC3200 DDR SDRAM would've been wasteful. Instead, we bought two 256MB sticks of Mushkin Basic Green PC2700 DDR SDRAM for $41 each. PC2700 memory will match up well with our motherboard.

For primary storage, we used a 7,200rpm, 80GB Western Digital SATA hard drive. Our drive is on the small side compared to other SATA drives on the market, but at $69.99, we felt it was a pretty good deal. If you find yourself needing to store a lot of voicemail and faxes, you can always add an additional SATA hard drive.

We did splurge on the optical drive, opting for an NEC 8X DVD burner for $64.99. If you're looking to save about $30, you can probably get by with a CD-RW drive, but the extra capacity offered by DVD will make backing up your system easier, especially if you need to back up a lot of voicemail or faxes.

We planned to go without the floppy drive, but the ASUS board won't let you install Windows to the SATA hard drive without installing special drivers via floppy disk. We found a black floppy drive to go with our case for $10.99.

Because our motherboard included integrated Ethernet and audio, we didn't shell out any money for a sound card or Ethernet card. We didn't want to spend a lot on our video card, so we settled on an Albatron NVIDIA GeForce 5600XT video card that we found for $87. We knew the card was going to perform horribly in 3DMark03 and PCMark04, but we don't need the latest 3D graphics to check email and send faxes.

Even if you have broadband, we recommend buying a modem for this

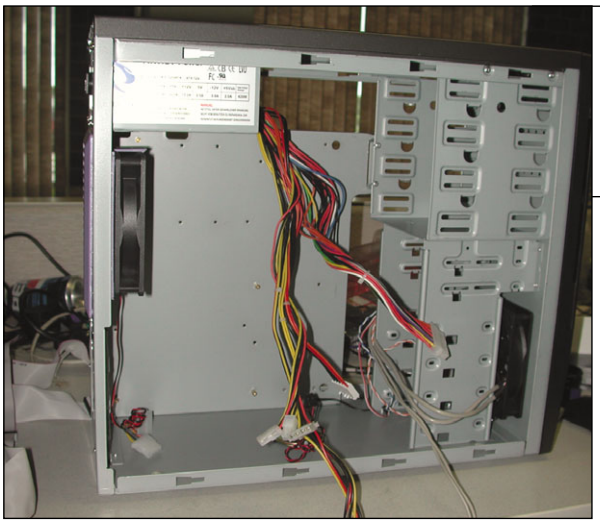
system as a way to send and receive faxes. We found an external U.S. Robotics 56K V.92 modem for $44.99. The modem is extremely easy to install as a single USB cable connects it to the system and provides power to the modem. Included software will give us voicemail capability, faxing capability, and even caller-ID capability.

We also wanted a piece of hardware to make this system stand out. We found Orange Micro's Blue2 kit, which includes a Jabra Bluetooth headset and a USB Bluetooth module. The headset will let us listen to voicemail while walking around the office. Paired with a VoIP service, the Orange Micro Blue2 kit will let you roam around your home office while talking on the phone. The Jabra headset is even compatible with Bluetooth-enabled cell phones.

We chose a RAIDMAX Silence 811TP case to house all of our components. The case looks better in a picture than it is in reality. It includes a digital temperature display built into the drive bay door. Unfortunately, the wire for the display tends to pull the drive bay door closed. The case isn't as solid as some of the others we've seen, but then again it was just $55 and included a 420W RAIDMAX power supply.

We cut corners on the keyboard and mouse, opting for a generic keyboard and mouse combo that cost just $10. The keyboard is decent, but the mouse isn't an optical mouse. If you can afford just a little more, you may want to invest in a slightly better optical mouse.

When we built our system, we actually used one of the many monitors lying around the office, but for budgeting purposes we found a ViewSonic E90B for $169 that would work with the $1,000 we had to spend on this system.



Before we begin, we'll need to remove both side panels from the case. This will let us screw our DVD burner, floppy drive, and hard drive to the case.

Finally, we finished off our system with an inexpensive Cintre RW-6580D 5.1 speaker system. The speakers only cost us $35.50, but you do have an opportunity here to further cut corners if you want. You only really need a two-speaker system, but the 5.1 system we opted for might come in handy for listening to an occasional song or watching an occasional DVD.

The Build

We started assembling the system by removing the left side panel from the case and removing the power cable inside the system. We were a little worried at first because we didn't see a hardware package containing the screws and standoffs we needed to mount the motherboard. When we removed the right side panel, however, we found the hardware sandwiched between the right side panel and the motherboard tray.

We set the case on its side and noticed the large 180mm rear case fan would make it difficult to install our motherboard. We removed the fan by slipping one end past the clip holding it to the case and then removing the other end. With the case clear, we removed the I/O faceplate in the back by pushing it in and out until it broke free from the case. Unfortunately, the hole left was too large to hold the I/O backplate that accompanied our motherboard, so we went without. Such is the price we paid for going with a $55 case.

We lowered the motherboard into the case to get an idea of where we needed to install standoffs. We removed the motherboard and screwed the standoffs into the appropriate positions.

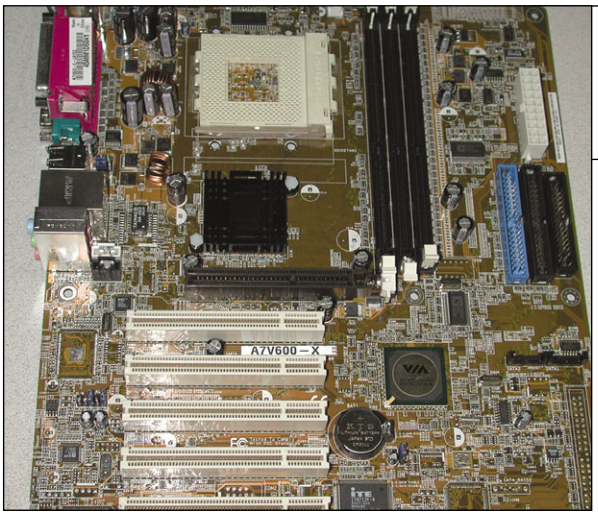
There's not a lot of room inside the case, so we figured it would be best to install the processor, heatsink, and RAM before we secured the motherboard to the case. We installed the Athlon XP processor into the ZIF socket and locked it in place. After spreading a thin layer of

Parts List

Case	RAIDMAX Silence (811TP)	$55
Power Supply	Included with case	
Motherboard	ASUS A7V600-X	$67
Processor	Athlon XP 2600+ (Barton)	$85
Memory	Mushkin Basic Green PC2700	$82
Hard Drive	Western Digital 80GB 7,200rpm	$69.99
Video Card	Albatron NVIDIA GeForce FX 5600XT	$87
Sound Card	Integrated	
Network Card	Integrated	
DVD Writer	NEC 8X Silver DVD±RW	$64.99
Diskette	NEC 1.44MB Floppy Drive (Black)	$10.99
Modem	U.S. Robotics 56K V.92 (USR5633A)	$44.99
Headset	Orange Micro Blue2	$109
Monitor	ViewSonic E90B 19-inch CRT*	$169
Speakers	Cintre RW-6580D	$35.50
Mouse	Included with keyboard	
Keyboard	Keyboard-2000 Smart 1	$10
OS	Windows XP SP1a (OEM)	$90
Total		**$980.46**

*Monitor not actually purchased, but its price fits within our alotted budget

thermal paste across the top of the die, we made sure the included heatsink was oriented properly (the notch was closest to the top of the system) and secured the bottom clamps to the plastic clips on the bottom of the socket. We then used a screwdriver to secure the top of the bracket to the plastic clips on the top of the socket and connected the fan to the proper header on the motherboard.



It's easiest to install the processor, heatsink, and fan before you install the motherboard.

We installed our memory modules to the two slots closest to the processor. We made sure to align the notch in each module with the notch in the slot and pressed each module firmly into the slot until the side clamps clipped firmly into place.

Once we had the processor, heatsink, and memory installed, it was time to install the motherboard. The case is a little small, so it was difficult to angle the motherboard into the case, but once it was in place we were able to easily secure it using the screws included with the case.

With the motherboard secure, we began wiring the case to the front-panel headers on the motherboard. Using the instructions included with our motherboard, we connected the leads for our case speaker, HDD LED, Power switch, and Reset switch. The digital readout on the drive bay door will act as the power LED and connect directly to our power supply.

Next, we wired the front USB ports to the case. Each port includes a 4-pin lead and a separate single-pin lead. We plugged one 4-pin lead into the top row of pins on the motherboard's USB header, making sure the red wire was nearest to the back of the case. Plug the single lead into the last pin on the top row. Connect the second 4-pin lead to the bottom row again, making sure the red wire is closest to the back of the case. There is no remaining pin in this row, so just let the last lead dangle in place.

If you want to use the front audio ports, you'll need to run the audio cables to the back of the system and plug them into the proper audio jacks on the motherboard. If you look directly at the back of the case, you'll see two small holes near the right side of the case. You can remove the cover for the lower hole by pushing in and out on the cover until it breaks free from the system. You can now work the audio cable out the back of the case. We connected the mic jack to the red mic-in jack on the motherboard and left the green line-out jack disconnected.

Next, we installed our hard drive and DVD burner. Unfortunately, the plastic covers protecting the 5.25-inch drive bays are difficult to reach. We used a screwdriver to push the front cover off. Be extremely careful when doing this, as the case managed to slice a thumb here. Repeat the procedure for the top 3.5-inch drive bay.

Next, we inserted the DVD burner and floppy drive into the empty drive bays and set them flush with the front of the case. We secured the drives to the case using four screws on each drive. Next, we inserted a hard drive into the upper-most internal 3.5-inch drive bay and secured the drive using four additional screws.

With the drive mounted, it was time to install our video card. The NVIDIA GeForce FX 5600XT isn't going to be your answer to Doom 3 goodness, but it'll be more than adequate for a communications system. The card inserted easily into the AGP slot after we removed the expansion cover on the back of the case.

We connected the SATA cable included with our motherboard to the top SATA port and connected the other end to our Western Digital SATA hard drive. We used the IDE cable included with the motherboard to connect the DVD burner to the motherboard.

Finally, it was time to connect the power supply. We unbundled the wires and connected the ATX power supply to the ATX power connector on the motherboard. Athlon XP motherboards lack a 12V input, so we left that alone. We connected the hard drive and DVD burner to the power supply along with the digital temperature display and front, rear, and side fans.

We sealed up the case and connected our monitor, speakers, keyboard, mouse, and Ethernet cable. We won't connect the modem or Bluetooth module until

System Notes	
Operating System	Windows XP Home
Processor	Athlon XP 2600+ (Barton)
RAM	512MB PC2700 DDR SDRAM
Bus Speed	333MHz
Hard Drive	80GB SATA
Optical Drive	8X NEC DVD±RW
Connectivity	Ethernet; Modem; Bluetooth
Video Card	NVIDIA GeForce FX 5600XT
Video RAM	128MB
Monitor	19-inch CRT
Sound Card/Speakers	5.1-channel surround sound
Chassis Size (inches)	20.6h x 8.1w x 18.6d
Weight	24.56 lbs
Benchmarks	
3DMark03	2793
PCMark04	3139
CPU Score	1985
Memory Score	861
Graphics Score	5065
HDD Score	869

after we get Windows up and running. We then booted up the system for the first time and prepared to install Windows XP.

WinXP. WinXP installation isn't difficult, but the SATA drive does put a small twist on the installation. We downloaded third-party drivers from the ASUS Web site (usa.asus.com). From the main page, we clicked Downloads, selected Motherboards in the Product menu, scrolled down to SocketA (462), and selected our A7V600-X. We clicked the Drivers link and selected the VIARAID220d.zip because it was the newest driver available. After we downloaded the file, we found a MakeDisk.exe program in the DriverDisk subdirectory. We inserted a diskette into the floppy drive and double-clicked MakeDisk.exe to create the boot disk.

As soon as we saw the initial blue install screen, we pushed F6 to let the installer know we needed to load third-party drivers. The installer continued to copy files before stopping and prompting us to load our third-party drivers. We pressed *S* and inserted the floppy disk when prompted. We selected VIA Serial ATA RAID Controller (Windows XP) and pressed ENTER to continue with the installation. The rest of the Windows installation was pretty straightforward.

Drivers. Because our system was live on the Internet, our first order of business after installing WinXP was to install critical updates from Windows Updates. After installing the updates and rebooting the system, we installed the drivers and software that came with our motherboard. Next, we installed the video driver for our NVIDIA card and rebooted the system so that we could run at a more pleasing resolution.

Once we had the basics installed, it was time to install the modem and Bluetooth headset. To connect the modem, we simply plugged one end of the included USB cable into the computer and plugged the other end into the modem. Cancel out of the Found New Hardware Wizard when it appears, insert the included CD-ROM, and install the software included with the modem.

Install the drives to the proper drive bays.

Before you install the Orange Micro Blue2 kit, make sure audio is working properly on your system. After installing the software from the CD-ROM, we connected the Blue2 USB module to the front USB port. A configuration wizard walked us through configuring the computer and headset to work together.

Once you have everything configured, you can use Sounds And Audio Devices in the Control Panel to switch between the speakers and the headset. To use the headset, click the Audio tab and select Bluetooth Audio for the Default Device in the Sound Playback and Sound Recording sections. Click the Voice tab and select Bluetooth Audio for Voice Playback and Voice Recording. Click the Apply button.

To test out the headset, click the Sounds tab, select a Program Event at the bottom with a speaker next to it, and click the Play button next to the Sounds field. You should hear the sound coming from the headset. To test the voice recording, click the Start menu, select All Programs and Accessories followed by Entertainment, and finally click Sound Recorder. Click the Record button and speak into the headset. Click stop when finished and click the playback button to listen to your recording. To round things out, we installed some open-source apps to handle email and Web browsing. We installed Mozilla Firebird as our default Web browser because we like its support for tabbed browsing and browser extensions. Firebird also seems to have fewer major security glitches compared to IE. For email, we used Thunderbird, also from Mozilla. Thunderbird is not only free, but it also has a great spam filter built in.

Of course, what's a communication system without IM? We installed the major IM applications including Yahoo! Messenger, MSN Messenger, AIM, and ICQ.

Testing

Our communications system didn't put up the best performance numbers, but you don't need a smoking system to handle voicemail, email, and fax. The system managed a meager 2793 overall score in PCMark04. The PCMark04 Graphics score was the most disappointing at 861, but the Memory score was a close second at 1985. The 3139 CPU score wasn't overly impressive, either. The 5065 HDD score, on the other hand, was very good for a single SATA hard drive. Given our PCMark04 scores, we weren't too surprised at the pathetic 869 3DMark03 score.

Final Remarks

Of course, the 3DMark03 score didn't hurt too much considering this system was never intended to play Doom 3. The system has more than the adequate performance to accomplish the tasks we had in mind at the start. The Phone Tools software included with our modem handles voicemail and faxes, and we liked the Caller ID software. Even though we didn't use the modem to connect to the Internet, we found it highly useful for faxes and voicemail. In reality, the Orange Micro Blue2 wasn't as useful as we had hoped, but again we think it'd be a great piece of hardware to use in conjunction with a VoIP service or software such as NetMeeting. RS

by Chad Denton

Best Heavy-Duty Server For Under $2,000

Host Your Own Web Site

Build #9 Skill Level: 1 2 3 4 5 *Master*

If you want to throw some pictures of your children onto the Web so your parents can see their grandkids from afar, you'll probably want to find a Web hosting service that will host your personal Web site for a small fee. However, if you have a small business and want to have more control over your Web presence than a Web host can provide, you'll want to build your own server.

Goal

We planned to build a Web server that would have enough storage to host a small business' Web site and would be fast enough to handle heavy loads. We set a target budget of $2,000 for our system.

Background

Windows XP Home and Professional make solid desktop operating systems, but they don't offer the kinds of server features that Windows Server provides. We suspected that our server's OS would swallow a large chunk of our budget, so we searched for it first. We were right: Windows Server 2003 is available for about $670, more than a quarter of our budget. We panicked, but then we discovered Windows Server 2003 Web Edition, which weighs in at a more reasonable $359.

A $311 difference suggests that Web Edition lacks more than one or two of the Standard Edition's features, so we looked into the cheaper version. We didn't want a crippled OS, but the program's name suggested that it might be right up our alley. Neither the Standard nor the Web Edition support Itaniums, but Standard supports up to 4GB of memory, whereas Web supports only 2GB. We weren't even sure that we'd be able to afford 2GB of memory, so we weren't broken up about that. Although Web Edition lacks a few features that Standard Edition has, such as Fax Service and Mac services, the Web Edition generally has stripped-down versions of many Standard Edition features, including VPN support and IntelliMirror, a policy management tool. We also looked for features that we would need when we presented our Web site to the world. The OS includes support for Microsoft's .NET framework and IIS (Internet Information Services) 6.0.

Next, we poked around for a case that could handle our server. We liked the Chenming 601AEBL-U-0, which offered four 5.25-inch drive bays and two external 3.5-inch bays. The case also included two case fans and boasted two front USB ports and a front FireWire port. However, we weren't planning to use the front-panel ports, and we already had the slightly larger Chenming 901AD-BLUE-0, which has five 5.25-inch bays. Both cases have drive runners that let you easily add and remove optical drives. The smaller case was cheaper ($55), but we decided to stick with the case that we had in-house, which retails for about $75.

The operating system supports dual processors, so we decided to toss two of Intel's popular Xeon processors into the mix. Before we narrowed our selection beyond the brand and series, we searched for a board that could handle two powerful CPUs. We decided to use the ASUS PC-DL Deluxe, which has two Xeon sockets and supports memory at speeds up to PC2700. The board has a 533MHz bus and supports several RAID configurations, including RAID 0 and RAID 1. We planned to set up a RAID 1 (mirrored) array, which wouldn't provide as much speed as RAID 0 (striped), but offered more security. In a RAID 1 array, your system writes data to both hard drives (one hard drive mirrors the other), which means that if one of your hard drives fails, the other hard drive will support your system without any loss of data. You can replace the defective drive with a new one without downtime, a feature that's crucial to server administrators. Although you'll (hopefully) back up your system regularly, you won't want to waste time loading the backup onto a hard drive while your server sits offline. Despite the RAID 1 array's obvious benefits, it has a serious drawback: The mirrored drives mean that in a two-hard drive system, you'll have only one hard drive's storage space instead of two. Think of it this way: You're paying double for a hard drive, but you're also buying a certain amount of security.

Now that we had the ASUS PC-DL Deluxe, we focused our attention on the Xeon processors. We chose two 2.8GHz

Intel Xeon processors, each of which boasts a 1MB L3 cache and a 533MHz FSB. The processors also included their own heatsink/fan combos and three-year warranties. At $339 a piece, they weren't cheap, but they couldn't hold a candle to the budget-smashing, top-of-the-line $695 3.2GHz Xeons.

The motherboard can handle up to 4GB of memory at this speed, but our operating system supported only 2GB of memory, and we didn't have enough money in our budget to buy 2GB anyway. Instead we bought 1GB of Kingston ValueRam. The board doesn't have strict memory requirements (unlike Opteron boards, which require registered ECC memory), so we didn't have any trouble finding two identical 512MB DIMMs that met our own strict budget requirements. We were surprised to find that even 1GB of ValueRam cost $177.

The PC-DL Deluxe doesn't include an integrated graphics chip, but it does have an AGP slot, which meant we had to add our own card. If we didn't have any spare parts on hand, we would have bought the cheapest card we could find: After all, we're not planning to game or edit graphics with this system. However, we had a 128MB PNY NVIDIA GeForce FX 5700LE handy, so we threw it into our system. At $133, the card costs much more than we would have spent on a graphics card for this type of system. When we later compared our system's total to our budget, we noticed that the video card accounted for a large part of the expenses that exceeded our budget.

Although we wanted plenty of storage space (in case we expanded our Web site in the future), we also wanted speed: The faster your hard drives, the faster your system can serve up Web pages. We settled on two 74GB Western Digital Raptor SATA drives, which boast speeds of 10,000rpm. If you plan to build a RAID 1 array, be sure to use two identical drives. If one of your drives is larger than the other, your system may recognize only as much storage space as the smallest drive provides. The motherboard offers four SATA connectors and three IDE connectors, which means we can add more storage when we upgrade the system. In fact, the board supports simultaneous RAID 0 and RAID 1 configurations.

Our Chenming case includes driver runners that let you quickly add and remove optical drives.

Finally, we dug up the rest of our server's necessities. We chose the ASUS CDS520 CD-ROM, which meets our optical drive needs and costs only $21. We grabbed a floppy drive, mouse, and keyboard from a nearby computer. If we bought the keyboard and mouse, we would have looked for a cheap bundle, as we don't plan to spend as much time typing at our server as we do with desktops and notebooks. We probably would have bought the Logitech Desktop Deluxe Bundle, which is available for $11.

We also bought a power supply. Unlike some Opteron-based motherboards, such as the MSI K8T Master2-FAR, which supports both SSI (Server System Infrastructure) and standard ATX power supplies, the PC-DL Deluxe supports only SSI PSUs. As a result, the motherboard has a 24-pin power connector (instead of the standard 20-pin connector) and an 8-pin 12V connector (instead of the standard 4-pin connector). Keep this in mind when you search for your server's case; a power supply that accompanies a case probably won't have the SSI connectors. We chose the 550W Fortron, which offered plenty of power and the right connections.

The Build

The Chenming case has plenty of elbow room and removable hard drive cages, which meant that we were able to work without bumping into things or cutting ourselves on case edges. A horizontal panel separates the top half of the case from the bottom, but a hole in the center and a gap near the back of the case let us route power cables into the motherboard area and data cables to the optical drive area.

We installed our optical drive without a hitch. We removed the top half of the front panel by pressing the panel's two side buttons, screwed drive runners into the optical drive so that the tabs face toward the front of the drive, and slid it into the bay. Our motherboard didn't include particularly long IDE cables and we didn't buy any extras, so we had to put the drive in the second bay from the bottom of the 5.25-inch bay area. We also installed the

Parts List		
Case	Chenming 901AD-BLUE-0	$75
Motherboard	ASUS PC-DL Deluxe	$201
Processor	Xeon 2.8AGHz (x2)	$678
Memory	Kingston PC2700 (512MBx2)	$177
Hard Drives	Western Digital WD740GD 10,000rpm (x2)	$376
Video Card	PNY NVIDIA GeForce FX5700LE	$133
Optical Drive	ASUS CDS520*	$21
Floppy Drive	Generic*	$8
Sound Card	Integrated	$0
Mouse & Keyboard	Logitech Desktop Deluxe Bundle**	$11
Operating System	Windows Server 2003 Web Edition	$359
PSU	550W Fortron FSP550-60PLN RET	$91
Miscellaneous	Thermaltake 80mm TT-8025A-2B Case Fans (x3)**	$15
Total		**$2,145**

* Equipment previously purchased
** Used similar in-house item

You can install two 3.5-inch devices in the removable drive sled. Notice that only the top half of the panel has been removed.

floppy drive without any trouble, thanks to the removable drive sled.

Installing the CPUs. You'll need a Phillip's head screwdriver and plenty of patience when you install Intel's Xeon processors. We pulled the first 2.8GHz processor from its packaging and held it over the socket so we could match the small triangle that sits on one corner of the processor to the small triangle hole on a corner of the socket. Once we matched the two triangles, we lifted the socket's lever. You can lift the lever before you even touch the processor if you want to, but make sure you lift it before you put the CPU on the socket. Until you lift the lever, you won't be able to fit the processor into the locked socket holes and you may bend the processor's pins. We pressed the CPU gently into place (without touching the metal processor case) and then snapped the lever back into place.

Next, we placed the metal backplate under the motherboard and put the black plastic retention frame over the CPU socket so that both components' holes matched the motherboard socket area's four holes. We used the included screws to bring the items together. Resist the urge to install the second processor's backplate and retention frame right away. Unlike AMD heatsinks, which often have very low retention frames, the Xeon's retention frame has two tall bridges that will get in the way when you install the processor.

Although some slower Xeons include heatsinks that have thermal pads, our Xeons had bare heatsinks, which meant that we needed to apply thermal paste before we placed them on top of the processors. Luckily, Intel tossed a thermal-paste-filled syringe into each processor package. We squeezed a dab of thermal paste onto the center of the processor and lowered the heatsink between the bridges until it rested on the processor inside the retention frame. Next, we secured the heatsink to the retention frame by applying two metal brackets. The brackets don't have hooks for screwdrivers, which means you'll need to use your fingers to attach them. If you can't attach a bracket without using a tool to force it, you should make sure you have the bracket in the right place. We slipped the bracket's center clip over the retention frame's hook and then slid the bracket away from the extended portion of the center clip's hole. We pushed one of the bracket's side clips over the retention frame's side hooks and then slid the bracket toward the other hook so we could press the other end of the bracket onto the retention frame.

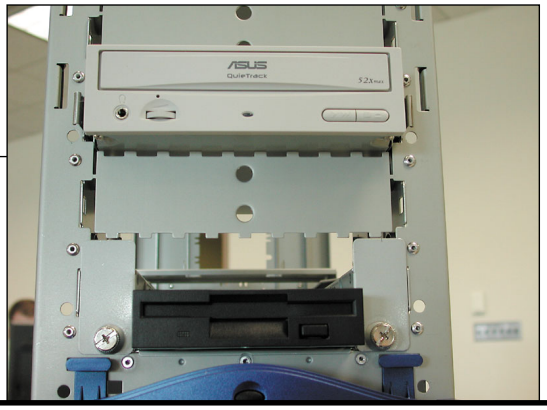
We attached the other bracket in the same way and then turned our attention to the heatsink cover. The cover has two areas that accept fans: the side and the top. If your motherboard has room, you can attach the fan to the side of the cover, but if you have the PC-DL Deluxe, you'll attach the fan to the top of the cover, thanks to the northbridge and several capacitors that stand near the CPU sockets. We popped the plastic circle from the top of the cover and popped the included fan onto the cover's connectors, which snapped over the edge of the fan.

We lowered the cover over the heatsink, careful to keep it inside the retention frame's bridges. The bridges snapped over the edges of the cover, locking it into place. With our first processor installation complete, we turned to the next socket and began the process again. Once we installed both processors, we plugged their power cables into the motherboard's connectors.

Installing the motherboard. We installed our memory before we put the motherboard into the chassis. The PC-DL Deluxe has dual-channel DIMM sockets, which means that two sets of sockets can transfer data simultaneously. The board supports a single-DIMM configuration, but we wanted to take advantage of the dual-channel capability, so we put one DIMM in the first socket (closest to the northbridge) and then put the second DIMM into the third socket.

Next, we pushed the mobo's I/O port shield into the appropriate hole at the back of the chassis and screwed standoffs into the chassis' mobo panel. We lowered the motherboard into the case, pushed the ports into the I/O shield, and screwed the board to the standoffs.

We attached the data cables before we pushed the PSU's many cables into the



Don't push the drives all the way into the case. If you let the drives extend beyond the metal chassis, they'll stand flush with the plastic front panel.

System Notes			
System Type: Web Server			
Dimensions (inches; Tower Only)	26.4 high x 8.1 wide x 18.6 deep		
Weight (lbs.; Tower Only)	50.08		
Benchmarks			
We loaded a mock Web site onto our Web server and then ran Microsoft's Web Application Stress Tool, which simulates heavy site traffic.			
Number Of Threads	**Number Of Hits**	**Requests Per Second**	**Connection Socket Errors**
1,500	209,715	3,495.00	0
2,400	207,738	3,461.46	0
4,500	165,153	2,751.30	3,446
9,600	4,217	72.27	94,936

lower half of the chassis. We attached the SATA hard drive cables to the top two SATA connectors (SATA 1 and SATA 2) because we planned to use Intel's RAID utility. The RAID 1 and RAID 2 SATA connectors stand just below the connectors we used. Finally, we pushed a few of the PSU cables into the mobo area. The Fortron PSU includes only one SATA connector, so we attached the mobo's two-connector SATA adapter.

Configuring RAID. Before we used Intel's RAID configuration utility, we entered the system's BIOS by pressing DELETE during POST. We navigated to Advanced, Integrated Peripherals, OnChip Device and then scrolled to the bottom of the page, which had several SATA settings. We highlighted On-Chip Serial ATA and switched the field to Enhanced Mode. Next, we highlighted the SATA Mode field (which stands just above On-Chip Serial ATA) and switched it from IDE (the default setting) to RAID. By default, the Serial ATA Port0 Mode and Serial ATA Port1 Mode displayed the correct settings (SATA0 Master and SATA1 Master, respectively). Next, we backed out to Integrated Peripherals and entered Onboard Device. We switched the Operating Mode field from RAID to IDE and then pressed F10 to save the changes and reboot.

We entered the Intel RAID For Serial ATA-RAID Configurations Utility by pressing CTRL-I during POST. The utility's main page listed our two drives under the Non-Raid Disks category. We pressed 1 to enter the Create RAID Volume menu, which let us name our RAID volume (you can use up to 16 characters when you create a name). The second option, RAID Level, displayed RAID0(Stripe) by default. We wanted a mirror array, so we switched the field to the only other option, RAID1(Mirror). When we changed the field to RAID1 (Mirror), the next option, Strip Size, automatically switched to N/A (after all, we're not creating a striped array). We highlighted Create Volume and pressed ENTER. When the main menu appeared again, it displayed our new array.

Each of the two removable hard drive cages has a compartment that accepts an 80mm fan. We placed our fan so that it sucks cool air in from the front and then forces it over the hard drive and into the case.

Before we installed Windows, we inserted the motherboard's driver CD into a nearby computer and then navigated to Drivers\Chipset\IAA to get the SATA RAID drivers. We double-clicked the folder's MakeDisk utility, which loaded the drivers onto a floppy disk. We returned to our computer, inserted the Windows installation CD, and pressed F6 when the Press F6 If You Need To Install A Third Party SCSI Or RAID Driver message appeared. We loaded the Intel 82801ER SATA RAID Controller and completed the installation.

Testing

Generally, we use PCMark04 and 3DMark03 to test our systems and review systems. We tossed out 3DMark03 right away: We aren't interested in the server's game-playing capabilities. We also pitched PCMark04: the benchmark tests standard desktop performance and can't offer information about our system's capabilities as a Web server.

Instead, we downloaded Microsoft's free Web Application Stress Tool (search for it at www.microsoft.com/downloads), which simulates heavy traffic to your Web site. We threw together a basic Web site, attached a switch (but didn't connect to the Internet) and then configured the tool to pound our server with 1,500 threads for one minute. Our system handled 3,495 requests per second without producing any socket errors, so we bumped the threads to 2,400 and reran the test. The Web server's request rate didn't drop much (it handled 3,461.46), so we raised the number of connections to 4,500. This time, the server's request rate dropped to 2,751.3, and the server produced 3,446 connection errors.

Finally, we bumped the test's threads to 9,600. The server struggled mightily, producing 94,936 errors and a request rate of 72.27.

Final Remarks

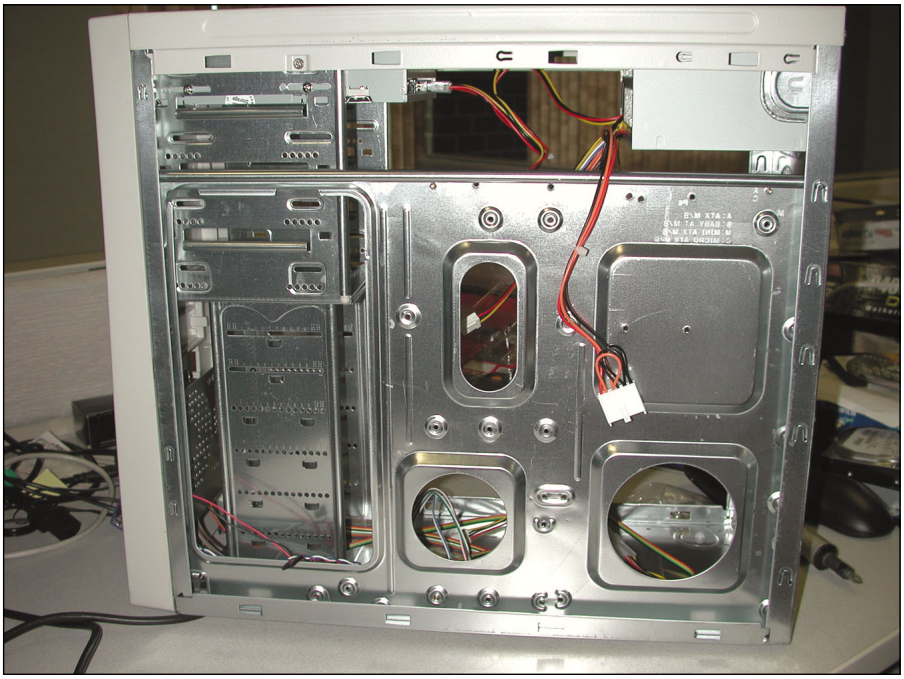
Our Web server may not have Intel's $695 3.2GHz Xeons, but it's no slouch. Even if our site draws 2,000 connections every minute, our server will hand out pages without missing a beat. Our system has solid components, but we probably should have bought a slightly smaller case: we doubt that we'll fill our Web server's five remaining optical drive bays. That said, we love our system's roomy interior. We won't have any trouble upgrading in the future. RS

by Joshua Gulick

Best Budget Linux Server Under $500

Serve Files To Your Network Or The World On A Budget

Build #10 Skill Level: 1 2 3 4 5 *Master*



Although computer hardware gets cheaper every day, $500 is still a small budget to build a system from scratch. Nonetheless, that was the amount allotted for our budget server, and that includes a monitor. Luckily, we could use open-source software for our server, so we didn't have to use any of our limited resources for software.

Goal

Our goal was to build the best server we could for under $500 using Linux and open-source software to cut down on expenses as much as possible. With such limited funds, the use of open-source software was important, as even Windows XP Home (not the best OS for a server) would use up almost a fifth of our total budget.

"Server" is kind of a generic term. We focused on configuring a Web server in this article, but software for creating mail and file servers is also readily available. We used Apache as our Web server. Entire books have been written on Apache, and we don't have a lot of room to get into particulars. Although we'll get your Web server up and running, we recommend you get more information on configuring and maintaining Apache. You can find official Apache2 documentation online (httpd.apache.org/docs-2.0).

Background

With just $500 to spend, you can forget about purchasing a real server processor. Both Intel's Xeon and AMD's Opteron are priced outside of our budget. Instead, we settled on an inexpensive AMD Athlon XP priced at just $85. We paired the processor with a $67 ASUS A7V600-X motherboard and $40 worth of Kingston PC3200 DDR SDRAM (256MB). These specifications aren't very impressive for a Web server, but for $500 you can't expect a server that can handle heavy loads.

Our 80GB, 7,200rpm SATA hard drive cost us $74. We would've loved to throw a DVD burner in this thing to make backing up your data easy. Heck, we would've loved it if we could've afforded a CD-RW drive. Instead, our budget forced a 52X CD-ROM drive on us. If you have another system on the network, you may want to consider network-based backups.

In WinXP, you need to use third-party drivers to install Windows on a SATA hard drive using this board. Our Linux distribution doesn't support third-party boot drivers, so we need a distribution with a Linux kernel that already supports SATA (a 2.6 series kernel). Because SATA support will already be a part of our OS (something Windows users can't say), we don't need a floppy drive at all. Although the average price of a floppy drive is just $10, we think we'll apply that $10 to other components and forgo the floppy drive.

We opted for an $87 AOpen GeForce FX 5600XT video card. NVIDIA cards are well-supported in Linux, and NVIDIA even provides 3D drivers for the OS (not that we'll need any of those for our server).

We found an amazing deal on a case. For just $22 we got ourselves a POWMAX 9804-4HL case and a 400W power supply. Granted, the case was pretty flimsy, but it'll do the job. The simple beige box isn't going to turn any heads, but does that really matter when you're trying to stick with a $500 budget?

Finally, we finished our shopping spree with a $10 Keyboard-2000 Smart 1 combo that included both a keyboard and a mouse. We found a 15-inch ViewSonic E55 CRT for $101, putting our grand total at exactly $500.

For our Linux distribution, we decided on Debian. Originally, we had intended to use the current stable version of Debian known as Woody. The Woody installer, however, doesn't come with a 2.6 series kernel, making it impossible to install Woody on our SATA drive. The Woody installer is also very difficult, and some of the software, although rock solid, is beginning to show its age. There are two other versions of Debian: Sid (Unstable) and Sarge (Testing). For the most part, Sid isn't as bad as its Unstable name implies, and it has the most up-to-date software. Nonetheless, it is possible for major bugs to work their way into Sid from time to time. Testing, or Sarge, will be the next official Debian release becoming Stable when the developers deem all outstanding bugs are eliminated. Testing is more current than Stable, and more stable than Unstable, making it a good compromise for us. The latest Sarge installer is also much easier than the Stable installer, and it includes an optional 2.6 series kernel.

If you're not familiar with Linux and would like some more background, the Web is full of resources. You can find plenty of Debian-related documentation on the project's Web site (www.debian.org/doc). DebianHELP (www.debianhelp.org) is a great Web site for Debian-specific news, information, and documentation. The Linux Documentation Project (www.tldp.org) contains a wide variety of generic HOWTO files. Finally, Linux.com (www.linux.com) is a great site for tutorials and news.

The Build

Without any loose change to spare for even a can of pop, we gathered our components together to begin the build. We started by removing both side panels and setting them aside. Make sure you place the side panels somewhere safe; they actually bend quite easily. While you're at it, you can remove the screw guard on the back of the system, as well. Remove the screw and push the screw guard up toward the top of the system.

We set the case on its side and lowered the motherboard into the case to get an idea where we needed to install standoffs. We screwed the standoffs into position and set the case aside while we installed the processor, heatsink, and memory onto the motherboard.

The Athlon XP dropped easily into the ZIF socket on the motherboard. We spread a small layer of thermal paste across the processor's die. We used the stock heatsink included with our retail processor. The heatsink has a large notch on one side that needs to line up with the raised portion of the processor socket. Once aligned, clip the heatsink clamps around the tabs on the socket. Using a screwdriver, clip the front clamps around the other set of tabs. Connect the CPU fan to the proper header on the motherboard.

We inserted our lone PC3200 memory module into the slot closest to the processor. After making sure the notch in the memory module matched the notch in the slot, we pressed straight down firmly until the module locked into place.

Our next step was to affix the motherboard assembly to the case. We lowered the case into position and used screws included with the case to secure the motherboard to the case. We then wired the HDD LED, Power LED, Power Switch, Reset Switch, and Speaker to the front-panel header on the motherboard. Consult the motherboard manual for the location of this header. Pay attention to positive and negative pins on the header; you need to attach the leads so that the colored wire is over the positive pin and the white wire is over the negative (or ground) pin.

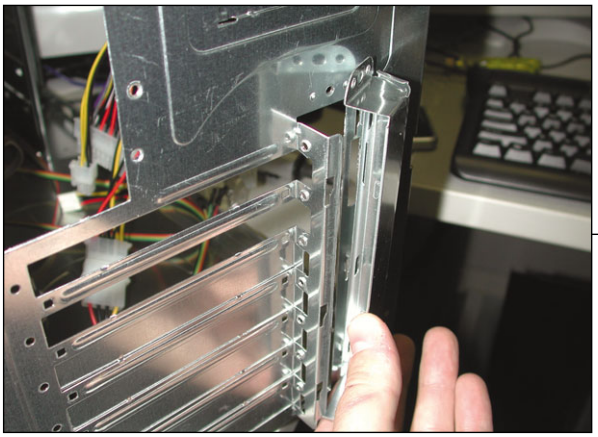
After the front panel was properly wired, we wired the front USB ports to the USB header on the motherboard (again, consult your documentation for location). Start by connecting the red wire from one USB port to a lower-left pin. Connect the yellow to the next pin, followed by the green and black wire. Repeat on the top row of pins with the second USB port. We

System Notes

Operating System	Debian (Testing/Sarge)
Processor	Athlon XP 2600+
RAM	256MB DDR SDRAM
Bus Speed	333MHz
Hard Drive	80GB SATA
Optical Drive	52X CD-ROM
Connectivity	10/100 Ethernet
Video Card	NVIDIA GeForce 5600XT
Video RAM	128MB
Monitor	15-inch CRT
Chassis Size (inches)	16.5H x 8W x 17.2D
Weight	16.58 lbs.

Parts List

Component	Model	Price
Case	POWMAX 9804-4HL-White	$22
Motherboard	ASUS A7V600-X	$67
Processor	Athlon XP 2600+	$85
Memory	Kingston 256MB PC3200 DDR SDRAM	$40
Hard Drive	Hitachi 80GB HDS 722580VLSA80 OEM	$74
Video Card	Albatron NVIDIA GeForce FX 5600XT	$87
Sound Card	Integrated	$0
Network Card	Integrated	$0
CD-ROM	Sony 52X CD-ROM	$14
Monitor	ViewSonic E55 15-inch CRT	$101
Mouse	Included With Keyboard	$0
Keyboard	Keyboard-2000 Smart 1	$10
OS	Debian Testing (Sarge)/Apache	$0
Total		**$500**



After removing the sides of the case, remove the screw securing the expansion slot screw cover. Lift up the cover to remove it from the case (this will make it much easier to secure your video card).

didn't bother with the audio cables (this is a server, not a jukebox).

We began installing our drives next. We used a screwdriver to remove one 5.25-inch plastic drive bay cover from the front of the case. We then twisted the metal drive bay guard until it broke free from the case. We slid our CD-ROM drive in place until it sat flush with the front of the case, and we used four screws to secure the drive. We inserted our hard drive into one of the internal 3.5-inch drive bays and secured it into place using four more screws.

Before we could insert our AGP card, we needed to remove the expansion slot cover from the case. To remove the cover, simply rock it back and forth until it breaks free from the case. Once the cover was out of the way, we inserted the AGP card into the slot and secured it to the case using a single screw. We only needed to install one card, so we went ahead and reattached the screw guard here.

With all of our components installed, all that was left was to wire the drives to the motherboard and connect the power. We started by connecting the CD-ROM drive to the primary IDE connector on the motherboard using the included IDE ribbon cable. We then used the SATA cable to connect our hard drive to the motherboard.

Our last step was to connect the ATX power supply to the motherboard and the 4-pin ATX connectors to the hard drive and CD-ROM drive. Once everything was in position, we closed up the case; connected our monitor, keyboard, mouse, and Ethernet cable; and booted up the system for the first time.

Testing

Before we began installing Debian, we needed to download and burn a copy of the new installer. At press time, you could find a copy of RC1 of the installer at www.debian.org/devel/debian-installer. We downloaded the ISO file to another system and used the Windows XP ISO Burner Power Toy(isorecorder.alexfeinman.com/isorecorder.htm) to burn the image to a CD-R.

Once we had our CD, we returned to our server. We pressed DEL during POST to access the BIOS setup utility and set the proper date and time. We also checked to make sure our processor was running at the correct speed. Once we had everything set, we inserted our boot CD, saved our settings, and rebooted the system.

At the boot prompt, we typed **linux26** to install the 2.6 series kernel we needed for our SATA hard drive. After choosing our language and keyboard settings, we entered a host and domain name for our system. We had the option to have Debian automatically partition our system for us, but we didn't like any of the default choices. Because we planned to use the system as a Web server, we wanted a system with a large /var partition, as we'll store our Web files in this partition. We selected Manually Edit Partition Table, selected Free Space, and opted to create a new partition. We typed **512MB** for the size of the partition, opted for a Primary rather than a Logical partition, and opted to create the partition at the beginning of the free space. Next, we selected Use As and chose Swap Area. We selected Done Setting Up Partition to move on.

Once again, we selected Free Space from the partition list and opted to Create A New Partition. We typed **60GB** for the size, selected Primary partition, and placed the new partition at the beginning of the free space. We selected Use As and chose ReiserFS Journaling File System from the list and then selected Mount Point and chose /var. Finally, we selected Done Setting Up This Partition.

We repeated this procedure to create a 10GB ReiserFS partition mounted as /usr, a 9GB partition mounted as /home, and a 1GB partition mounted as / (root). We made these partitions Logical partitions rather than Primary partitions and then selected Finish Partitioning And Write Changes To Disk. The installer formatted the partitions and began copying files to the hard drive. When asked, we opted to install Grub to the MBR (master boot record). We removed the CD when it ejected and let the system reboot.

After rebooting, we did some preliminary configuration (setting our time zone and creating a user account, for instance) and then were asked to configure Apt. Apt is the package-management utility that makes Debian so popular. We selected our country from the list and picked a mirror (any mirror will do, but we used mirrors.kernel.org). We didn't have an HTTP proxy, so we left this information

There's not a whole lot of space in this case, so it's best (and easiest) to install the processor, heatsink, and memory before you install the motherboard.

blank. Debian downloaded a list of files available for installation.

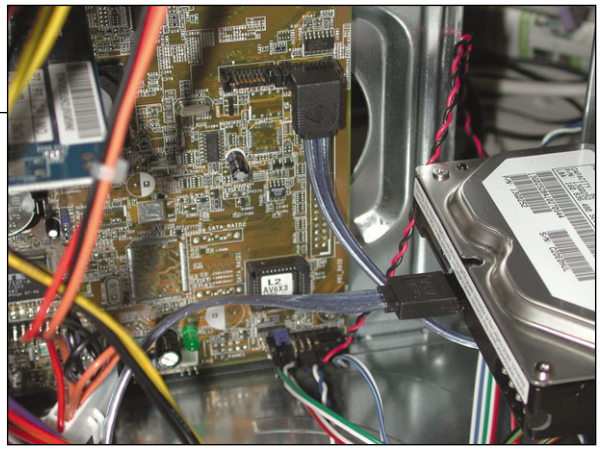
Next, we were presented with a Debian Software Selection menu. We selected Web Server here, but you may also want to select Print Server, File Server, or Mail Server. Select a category by highlighting it and pressing the Spacebar. Select OK to begin downloading and installing packages.

It took us about 25 minutes to download 621 packages. The number of packages may change as Sarge moves toward stable, and the total time it takes to install packages will vary depending on your Internet connection and network conditions. As Debian began installing the new packages, it occasionally prompted us for additional information.

When prompted to select an X Server, we selected NV. This is the 2D NVIDIA driver included with XFree86 (the X windows server that's the foundation for a graphical environment in Debian). We said no when asked if we wanted to attempt to autodetect our monitor settings and selected the Advanced configuration option. For the monitor's horizontal sync range, we specified 30-70, and for the vertical sync range, we specified 50-160 (if you use a different monitor, make sure you know these settings before proceeding).

Next, you'll be asked to configure Exim 4. We left Exim 4 unconfigured at this point. You can always reconfigure it later by typing **dpkg-reconfigure exim4-config**.

Finally, you should see a graphical login menu. Enter the username and password you created earlier to log in. Debian installed Apache2 by default. To make sure Apache is running, open a browser and type **http://127.0.0.1/apache2-default**. You should see a Web page telling you Apache is properly configured. Place any Web pages you want to make available in the /var/www/apache2-default directory.



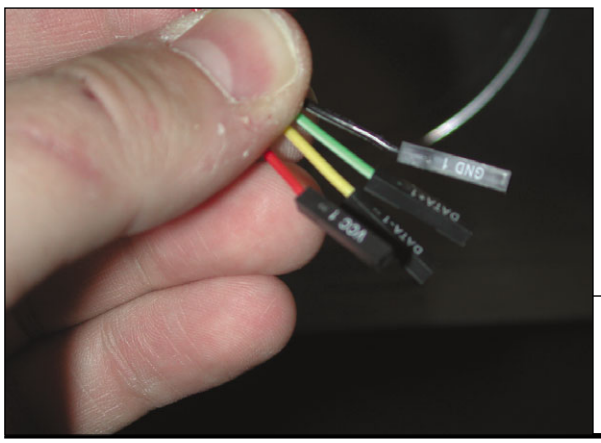
Connect the SATA hard drive to the SATA port on the motherboard.

Install Software. One of Debian's strongest features is Apt. Using Apt, you can easily install new packages and upgrade your system. To make Apt even easier, we'll use a graphical front end for Apt known as Synaptic. To use Synaptic, press ALT F2 and type **synaptic**. Enter the root password when prompted to continue.

You can browse through available packages (a package is a collection of files related to a specific program) by category or click the Find button to search for additional packages. For instance, you can upgrade to the latest kernel by searching for kernel-image and selecting kernel-image-2.6.7.1-k7 (to select a package, click the checkbox next to it and select Mark For Install). This is a special version of the 2.6.7 kernel compiled specifically for Athlon XP processors. Considering our hardware isn't the best, we upgraded the kernel to squeeze what performance we could from the system. We also searched for and installed KDM. When prompted, we opted to use KDM as our default login manager (this lets us restart the system without logging out of KDE, our graphical interface). Reboot the system to begin using the new software (the kernel is the rare exception; normally you don't have to reboot after installing software).

You can also upgrade the system from Synaptic. As developers continue to crush bugs, they'll add new packages to Sarge. To upgrade, click the Mark All Upgrades button. When prompted, select Smart Upgrade. Click Apply to download and install the packages.

Because of the way the installer configures Apt, you'll continue to use packages from testing after Sarge is officially released. If you want to continue to use Sarge after it becomes Stable, select Preferences and click Repositories. Select the second line and, in the fields below, change Testing to Sarge. Repeat for the third line.



The USB leads from the case are a little difficult to connect to the USB headers.

Final Results

Overall, the procedure is fairly straightforward. We do wish we had a CD or DVD burner to make it easier to back up files. Placing the /var directory on a separate partition does help a bit as you'll be able to reinstall without wiping out your Web files, but there is no replacement for good backups.

A larger budget would've given us better performance and maybe even Gigabit Ethernet connectivity. If we had the money, we would've considered a RAID array of some sort (RAID 0 if we wanted speed or RAID 1 if we wanted redundancy). We didn't have a penny in our budget to spare on such luxuries, however.

We do recommend you learn more about configuring and securing Apache. There simply isn't room in this article to discuss all the intricacies of Apache configuration. RS

by Chad Denton

Best Heavy-Duty Graphics/CAD Workstation For Under $3,000

Put Power Behind Your Talent

Build #11 Skill Level: 1 2 3 4 5 *Master*

Workstations get less attention than their more entertainment-oriented cousins, in part because so many users don't tackle the CAD and graphics tasks that workstations shoulder. Another factor is price. Although you won't double the system's performance by adding a second processor, you'll pay the same price for both processors (no "Buy one, get one half-off" deals when it comes to CPUs). That said, users who deal with heavy graphics-related tasks won't want to settle for the standard desktop. If you're running CAD applications on a tired, single-processor PC, read on.

Goal

Workstations are rarely pretty. They trade flashy items such as lights and windows for power and expandability. To that end, we planned to build a workstation that packed heavy-hitting processor, memory, and storage components. We also wanted to give our system a workstation graphics card that would let the user add a second monitor. However, we didn't put any of our budget toward monitors; we left the peripheral choices to you and instead focused on the tower.

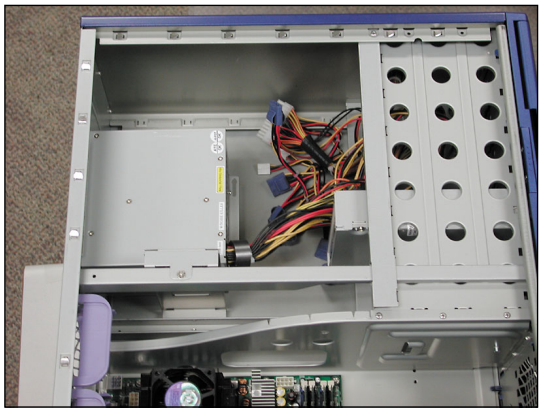
Background

Video editing, CAD, and graphics design eat up hard drive space, which means that no matter how many hard drives you buy at first, you'll be buying more drives later. Our budget, though large, wouldn't let us stock up on tons of hard drives, but if we were to use this system, we're sure we'd need more drives later. To that end, we searched for a chassis that boasted large drive bay capacities. We spotted an ultra-large Chenming case that fit the bill. It stores up to six hard drives in its two drive cages and has six external optical drive bays, which means we'll have plenty of room for additional optical drives (or hard drives in a pinch) later. And at $75, the case barely put a dent in our budget. We were glad to see that the case didn't include a power supply, as we knew that we'd need a special PSU and didn't want to waste money on an unnecessary accessory. Our giant blue beast has brackets for chassis fans but doesn't include any, so we picked up four 80mm fans (two for the front, two for the rear). We like the brackets, which make fan installation a breeze. However, the case is more than 2 feet tall, which means we won't be able to hide it under a low desk or table. That's a small price to pay for the extra storage space and elbow room.

Once we found the case, we searched for the foundation of our system: the motherboard. We planned to use two Xeon processors, which meant that we needed a Xeon-based motherboard. We liked the ASUS PC-DL Deluxe. The board has the 875P chipset, which supports a 533MHz bus and 4GB of DDR memory at speeds up to PC2700. We liked the mobo's extensive RAID support (what with our plans for multiple hard drives and all), which includes four SATA connectors and three IDE connectors. Thanks to the Promise controller and Intel ICH5R, the board supports RAID 0, 1, and 10. The PC-DL Deluxe also supports simultaneous RAID 0 and RAID 1 configurations.

CAD and graphics applications can never have too much power, so we tried to work two $695 3.2GHz Xeon's into our budget, but the roughly $1,400 cost would have slaughtered our plans to build a reasonably-priced system. We could have skimped on the rest of the components, but we wanted to put some serious cash into a decent workstation video card, so we settled for the 2.8AGHz Xeons, which together cost less than just one of our dream processors. Each 2.8AGHz processor has a 533MHz FSB and supports MMX, SSE, and SSE2 (but not SSE3) instructions and includes its own heatsink/fan unit.

Unlike Opteron-based motherboards, which require registered ECC memory,



The chassis has plenty of room for the PSU's many cords. Notice the center panel that separates the PSU from the motherboard area.

the PC-DL deluxe can handle standard unbuffered PC2700 DDR SDRAM. Again, we didn't want to eat up too much of the cash we planned to spend on the video card, but we didn't want to cripple our system by not buying enough memory, so we settled for 2GB of Kingston ValueRam in the form of four 512MB PC2700 DIMMs.

Next, we turned our attention to the graphics card. We searched for a workstation video card that would be able to handle heavy graphics and digital video editing and support dual monitors. We chose the ATI X2-256T, which boasts the FireGL 9800 chipset and 256MB of memory. It sports two DVI monitor connectors (and includes adapters for standard monitor connectors) and supports resolutions up to 2,048 x 1,536 at 85Hz. The card also has programmable pixel and vertex shaders.

Unfortunately, our high-power items shredded most of our budget, which meant that we couldn't afford a massive collection of hard drives. Rather than trying to hunt down as many rebate-bearing drives as we could find, we decided to focus instead on speed. We bought two 74GB Western Digital Raptor SATA drives, which set us back another $376. Sure, the drives don't afford a ton of space, but at 10,000rpm, they're much faster than standard drives. We planned to boost their speediness further by configuring them into a RAID 0 (striped) array (to learn more abut RAID array's see "RAID 0 Under $1,000 starting on page 92").

With the most important components in hand, we tracked down the rest of our system's guts. We would have bought the Plextor PX-712SA, which has fast DVD±RW burning speeds and several extra features, such as Silent Mode, but we already had a Plextor PX 708A, which has slightly slower burn speeds, so we popped it into our system instead. Next, we snagged a 550W Fortron SSI (Server System Infrastucture) power supply. Unlike standard ATX power supplies, which generally have 20-pin and 4-pin mobo connectors, the SSI PSU has a 24-pin connector and an 8-pin connector that match the mobo's connectors.

The Build

Thanks to the chassis' size and removable hard drive cages, you can install the components in any order you like. Normally, we suggest that you install the PSU toward the end of the build, so you won't have to negotiate stray cords, but the case's PSU section is so large that we don't think you'll run into that problem. You can easily store the cords above the PSU or in the large 5.25-inch bay area, assuming you don't have too many drives. When you move the cords back into the motherboard area of the case later, you'll find that you can push them through a large hole in the panel that separates the top half of the case from the lower half. The panel's shape also lets you slide a few cords through a gap directly under the PSU; if your mobo's PSU connector stands near the I/O ports (as ours does), you'll like this gap.

Installing the drives. We started with the floppy drive and optical drive. The 3.5-inch bay has a removable, dual-bay sled that let us quickly install the floppy drive without poking around inside the case. The 5.25-inch bays include drive runners, so we screwed them into our DVD±RW and then slid it back into the bay until the runners snapped into place. You can't install either type of drive without removing the top half of the front panel, but two buttons on the sides of the panel make this an easy process.

We didn't run into any problems when we installed the hard drives, either. Each of the removable cages has a tab that locks it into place; we simply pushed the tab, pulled out the cage, and then installed the drive via four of the case's many, many screws. We didn't attach the data and power cables just yet; no need to clog up the case before we installed the motherboard. Although the case is extremely tall, it's not much deeper than smaller cases (18.6 inches).

Installing the CPU. We pulled the chassis off the desk and replaced it with the PC-DL Deluxe, which we placed on top of its static-proof bag and foam box liner. Next, we grabbed one of our processors. Intel processors have large, bulky boxes, but we have to give Intel credit: You can easily open the package. Opteron packages, on the other hand, are a different story. We started by flipping up one of the socket levers and then dropping the CPU into the socket. If you've installed AMD or Intel processors before, you already know that one corner of the

Parts List

Case	Chenming 901AD-BLUE-0	$75
Motherboard	ASUS PC-DL Deluxe	$201
Processor	Xeon 2.8AGHz (x2)	$678
Memory	Kingston PC2700 (512MB x4)	$354
Hard Drives	Western Digital WD740GD 10,000rpm (x2)	$376
Video Card	ATI FireGL X2-256T	$715
Optical Drive	Plextor PX-712A **	$160
Floppy Drive	Generic*	$8
Sound Card	Creative Labs Audigy2 ZS PCI SB0350	$88
Mouse & Keyboard	Microsoft Wireless Optical Desktop Elite**	$75
Operating System	Windows XP Professional (OEM)	$141
PSU	550W Fortron FSP550-60PLN RET	$91
Miscellaneous	Thermaltake 80mm TT-8025A-2B Case Fans (x4)**	$20
Total		**$2,982**

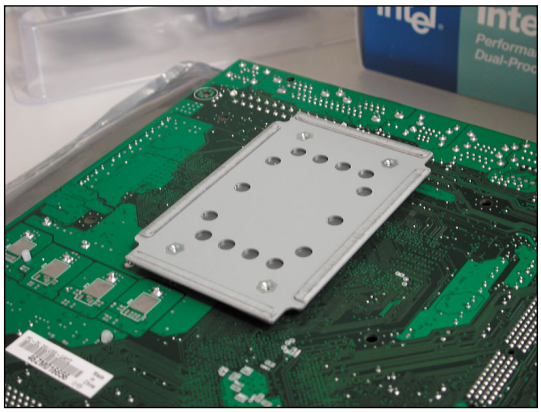
* Equipment previously purchased
** Used similar in-house item

processor has a small triangle marking. We matched that triangle to the triangle-shaped indentation on the corner of the CPU socket, which ensured that our processor's pins matched the corresponding holes. We were careful to make sure that the CPU sat neatly in the socket; if the socket is even just a little uneven, you won't be able to boot your system.

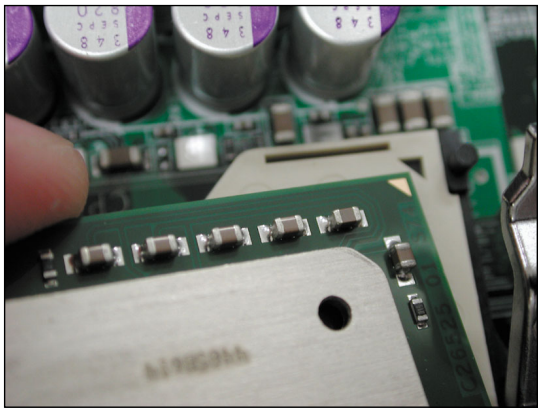
We snapped the lever back into place and grabbed the backplate. We slipped it under the board and then lined it up so that its four standoffs were even with the socket area's holes. Next, we placed the plastic retention frame onto the board so that its holes matched the holes below. Then, we used four screws to bring the backplate, mobo, and frame together.

Before we placed the aluminum and copper heatsink on top of the processor, we used the included syringe to dispense a small blob of thermal paste onto the center of the processor. We lowered the heatsink until it rested on the CPU and attached the two metal brackets that hold the heatsink to the retention frame. To attach a bracket, slip the center clip over the retention frame's corresponding hook and then look at the center clip's hole. The hole isn't a perfect circle; part of it extends to the left or the right. If it extends to the left, press the left clip over the left hook and slide the bracket to the right (so that the center hook enters the extended portion of the clip's hole) and then press the right clip over the right hook. You'll need to apply some pressure to push the hook down, but you won't need any tools.

Next, we attached the small fan to the plastic heatsink cover. You can attach the fan to the side of the cover, but our motherboard's capacitors and nearby northbridge didn't allow that type of configuration, so we popped off the small plastic circle at the top of the cover and then pressed the fan so that the cover's hooks snapped over the edge of the fan. We dropped the cover over the top of the heatsink so that the cover's sides slipped between the retention frame's bridges and then pressed down until they snapped into place. Although these heatsink/fan combos require a bigger time investment than AMD processor-based heatsinks (we can install an AMD heatsink in one or two minutes, but we spent about 10 minutes installing each Xeon heatsink), they don't require any tools.



Align the backplate's standoffs with the motherboard's four holes. You'll use the backplate to secure the retention frame to the board later.



Match the processor's triangle to the socket's triangle before dropping the CPU into place.

Once we snapped the cover onto the first Xeon, we installed the second processor and heatsink. Before we snapped the fan onto the cover, we located the mobo's CPU fan header and then positioned the fan so that the slack cable wrapped around the body of the fan. We didn't want to pull the cable taut (if the power connector slipped off, the processor would quickly overheat), but we also didn't want it to stick out into the case where it might tangle with the other cords.

System Notes	
System Type: Graphics Workstation	
Dimensions (Inches; Tower Only)	26.4h x 8.1w x 18.6d
Weight (lbs; Tower Only)	50.08

Benchmarks	
We ran PCMark04 (version 1.2.0, with Windows Media Player 9) and 3DMark03 (build 340, with DirectX 9) at default settings. We used ATI's Unified FireGL driver version 7.96.2.1.	
PCMark04	**5317**
CPU	5116
Memory	3894
Graphics	4465
Hard Drive	8128
3DMark03	**6118**

With our processors out of the way, we looked for other components we could install before we put the motherboard inside the chassis. The video card and sound card required the chassis, but our memory didn't, so we installed our 2GB of PC2700 DIMMs. We didn't have to worry about which slots we needed to put the memory in: The board has four memory slots, and we had four identical DIMMs.

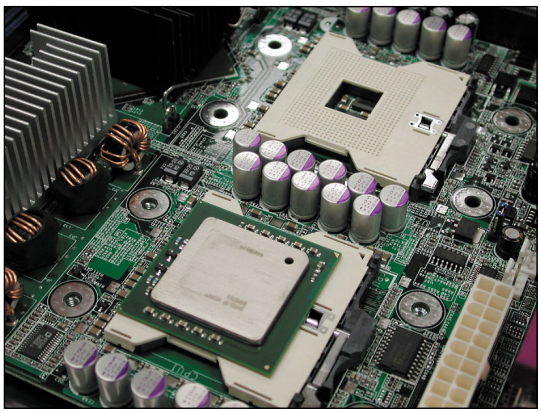
Installing the motherboard. We pulled our hard drive cages out of the system, lowered the motherboard onto the standoffs, and replaced the cages. Our motherboard sports 10 standoff holes because the left side of the board (which faces the back of the computer) had four holes instead of the usual three. We were glad to see that the extra hole stands just in front of the PCI slots, which meant that the board had a little more support when we pushed the sound card into its slot.

Next, we pushed our FireGL video card into the AGP slot. The AGP slot doesn't have the popular hook that catches the AGP card's back hook, but the card fits firmly in the slot, so we're not complaining. We popped the sound card into one of the PCI slots and then turned our attention to the data cables. We plugged the IDE and floppy cables into the drives and then slipped them through the hole of the panel above the motherboard. The board has three IDE ports, one of which points toward the front of the computer instead of toward the side panel. Don't plug your

optical drive cable into this port. It's for RAID hard drive configurations.

We also attached the SATA cables, which are thin, red (in the case of the PC-DL Deluxe) cables that attach to the four black SATA connectors that stand near the IDE connectors. We planned to use Intel's RAID utility, so we plugged our cables into the top two connectors. If you want to use the Promise RAID controller, you can attach the cables to the bottom two connectors.

We wrapped up the build by screwing the PSU into the back of the case and then dropping the power cables through the panel's hole. We plugged the standard connectors into the optical drive and graphics card. The PSU includes only one SATA power connector, but we added two more by plugging the motherboard's SATA adapter into one of the standard 4-pin connectors. We plugged the 24-pin and 8-pin connectors into the motherboard, double-checked the PSU fan connectors, and powered on the system.



Be sure to raise the socket lever before you insert the CPU and then lower it again to secure the processor.

Configuring RAID. We entered the BIOS by pressing the DELETE key when the ASUS logo appeared and then used the arrow keys to select the Advanced tab. We chose the Integrated Peripherals menu, which has several submenus, including OnChip IDE Device and Onboard Device. We entered OnChip Device first and scrolled to the bottom of the menu where we found the SATA settings. By default, the SATA Mode field was set to IDE, but the field was gray, which meant that we couldn't change it right away. Instead, we highlighted On-Chip Serial ATA, pressed ENTER, and selected Enhanced Mode. When we pressed Enter again, the SATA Mode field became bright, so we selected it and changed the mode to RAID. We double-checked to make sure that the Serial ATA Port0 Mode was set to SATA0 Master and that the Serial ATA Port1 Mode was set to SATA1 Master and then pressed ESC to return to the Integrated Peripherals. Next, we entered the Onboard Device menu and then switched the Operating Mode field from RAID to IDE. We pressed F10 to save the changes and *Y* to reboot.

Now that our BIOS was properly configured for RAID, we entered the Intel RAID For Serial ATA-RAID Configuration Utility (by pressing CTRL-I during POST) so we could configure a RAID 0 array. When your system writes data to a RAID 0 array, it breaks up the data and writes half to each disk, speeding the write time.

The RAID Configuration Utility's main menu displayed our two Western Digital hard drives in the Non-RAID Disks category. We chose the first option, Create RAID Volume, which opened the Create Array menu. By default, the utility named our soon-to-be RAID array RAID_Volume1. You can change the array's name here (it accepts up to 16 characters). The next option, RAID Level, displayed RAID0(Stripe). The utility also offers RAID 1, but we wanted the striped array, so we left this field the way it was and then selected Create Volume. We pressed *Y* at the Are You Sure You Want To Create This Volume screen. The main menu appeared after a couple seconds, displaying our drives under RAID Volumes. We exited the utility and grabbed the motherboard CD and floppy before heading to a nearby computer.

If you use the Intel RAID utility to configure your SATA drives, you'll need to install the IAA (Intel Application Accelerator [RAID Edition]) driver during Windows setup. We put the mobo driver CD into a functional computer, opened the CD, and then navigated to the IAA MakeDisk utility (DRIVERS\CHIPSET\IAA). We double-clicked the MakeDisk utility, which loaded the appropriate drivers onto our floppy disk.

Next, we returned to our computer and inserted the Windows XP Professional installation CD. We pressed F6 when the Press F6 If You Need To Install A Third Party SCSI Or RAID Driver message appeared and then pressed *S* when Windows Setup couldn't find our hard drives. We inserted the floppy drive, pressed ENTER, and selected Intel 82801ER SATA RAID Controller. Windows Setup loaded the drivers and then completed the installation without a hitch.

Testing

Once we installed our system's drivers (including video card, sound card, and motherboard drivers), we loaded our benchmarks: PCMark04 and 3DMark03. Our workstation produced a solid 5317 in PCMark04, but we found the individual component scores more important than its overall performance. We liked the 5116 CPU score and the 4465 Graphics score, but we were excited to see an HDD score of 8128. Our system also performed well in 3DMark03, weighing in at 6118.

Final Remarks

Between the RAID array and dual processors, we expected a few hiccups, but we built our workstation, powered it on, and benchmarked it without running into any trouble. Although our system doesn't have much storage space at the moment, the chassis and RAID-friendly motherboard offer plenty of expansion possibilities.

Of course, our system wouldn't be ready for action until we installed CAD or digital video-editing software. Although basic amateur versions won't cut deep into your budget, they also won't do your system justice. If you plan to build a workstation, expand your budget to cover your favorite apps. RS

by Joshua Gulick

Best Video & Still Photo-Editing/ Printing System For Under $2,000

Avoid Graphical Slowdowns & Get Stunning Results

Build #12 Skill Level: 1 2 **3** 4 5 ***Journeyman***

Photoshop is a Pentium III's worst enemy. The demands of digital video eat outdated AMD CPUs alive. That should tell you that an average machine won't handle the demands of still-photo manipulation and digital video editing. These applications require fast CPUs and a lot of RAM to keep your processes running at a high speed; otherwise, you'll end up with a lot of crashed programs and endless exasperation as you wait for your computer to complete its jobs.

It's certainly not hard to build a computer to satisfy the needs for editing both still and moving images. The only problems arise when you have to select parts on a $2,000 budget.

Goal

We set out to gather a collection of components that we thought would make for a well-rounded home office PC worthy of taking on most editing tasks. We initially planned to use an AMD Athlon XP 2800+ in this machine, and we figured PC2700 RAM would be fast enough for most purposes. Then we found an ASUS A7V600 motherboard for a low price and saw that it supported PC3200 RAM. We upgraded our RAM, and because it didn't seem to make sense to leave our CPU out in the cold, we stepped up here, too, to an Athlon XP 3000+ with 400MHz frontside bus speed. These minor upgrades should add punch to the system's power and extend its lifetime by at least a few months.

Background

Storage was a major concern. Images from high-resolution digital cameras can easily consume between 2 and 10MB each. Digital video devours as much as 1.5GB per minute, which means that a 30-minute clip could take 45GB or more of precious disk capacity. We knew we'd delete a lot of these clips during the editing process, but this kind of data still requires a massive hard drive. We originally wanted a 250GB behemoth, but the Western Digital drives we located cost nearly $215, almost $80 more than a 200GB drive we found for less than $140. With our limited budget being used to splurge on many other toys, we opted for the latter drive, which is plenty beefy for the average home user.

Of course, we needed more than just a hard drive for our files. We also wanted a way to archive video and images, so it was obvious that a DVD burner was in our future. We chose a Samsung 8X internal DVD±RW drive that sold for well under $100.

There was no sense in wasting the talents of an imaging machine by investing in an average 17-inch monitor. We found a 21-inch flat-screen Sony CRT online for only $300, and though we weren't able to order this monstrous monitor due to in-house budget restrictions, we left it in our chart so that you'll know you can fit one into a budget similar to ours. We didn't even consider looking at LCD monitors because of their high prices.

Bling Bling

CRT monitors are much cheaper than fancier LCDs, but they're also better for high-resolution graphics and accurate colors. So, take the money you budgeted for a nice LCD and go crazy with a huge CRT. ▲

To make our CRT go, we dropped a large chunk of change on an ATI Radeon Pro 9800 (256MB) video card. This card won't have any problems handling the demands of video or still images, and it has garnered rave reviews from gamers, who regularly run software that pushes their graphics-related hardware to the limits.

Because our motherboard didn't come with integrated FireWire ports, we found a FireWire card to slip into a PCI slot. We picked a SIIG FireWire 800 PCI-32T Host Adapter that added two FireWire 800 ports and one FireWire 400 port to our PC.

Perfect peripherals. We didn't think our editing system would be complete without a nice range of appropriate input and output devices. To round out our machine, we selected a photo printer, scanner, and color calibration device.

The printer was an easy decision. We picked the Epson Stylus Photo R200, a photo-specific printer that uses six inks for improved color gradations, and it does so with individual ink cartridges. That means you can replace ink as it runs out without having to toss a tricolor tank that might still have significant amounts of another color remaining.

We found a flatbed scanner that was inexpensive yet powerful. For less than $60 we picked up a solid Canon scanner with 600 x 1,200 resolution and 48-bit color, which is enough to create high-quality input for our photo-editing sessions.

If you've ever toyed with photo printing and experienced color-matching problems when monitor images look totally different than your final prints, we understand your frustration. That's why we invested a sizable chunk of our budget in the Pantone/ ColorVision Spyder Pro colorimeter bundled with ColorVision's OptiCAL and ProfilerPLUS, the software programs that

Parts List

Component	Model	Price
Case	Aspire Blue ATX Mid-Tower Case with 350W TurboLink PSU	$45
Motherboard	ASUS A7V600 KT600 Chipset Motherboard	$76
Processor	AMD Athlon XP 3000+ (400 FSB)	$135
Memory	Corsair 1GB Kit DDR400 Value Select Memory (VS1GBKIT333)	$175
Hard Drive	Western Digital 200GB 7,200rpm SATA Hard Drive (WD2000JD)	$136
Video Card	ATI Radeon 9800 Pro Video Card (256MB DDR)	$265
Optical Drive	Samsung 8X Internal DVD±RW Drive (SH-W08ARNS)	$84
Monitor	21-inch Sony Flat Screen Trinitron Monitor (GDM-5411)	$299
Floppy Drive	Generic Floppy Drive	$7
Mouse	Logitech Premium Optical Wheel Mouse	$12
Keyboard	Generic Computer PS/2 Keyboard	$7
Operating System	Windows XP Home Edition	$90
Miscellaneous	ColorVision Spyder Colorimeter Photo Suite Pro for LCD/CRT Monitor	$299
	Pinnacle Studio 9 AV/DV	$95
	Photoshop Elements 2.0	$91
	Epson Stylus Photo R200	$92
	Canon CanoScan LiDE 20 Scanner	$52
	i-Rocks 10-in-1 Flash Card Reader/Writer	$20
	Speeze Socket A and 370 CPU Cooling Fan/Copper Core	$15
Total		**$1,995**

help drive the system. You can buy the colorimeter alone for a lower price (and with a variety different programs), but considering the capabilities of the complete system, we didn't want to sell ourselves short.

In a nutshell, the Spyder Pro, with the help of the software we bought, calibrates your CRT or LCD monitor to work with your printer. That helps ensure that the photos you see on your screen look just like hard-copy prints, a fact that saves wasted ink and paper and makes for much more productive printing sessions. All you have to do is print a calibration chart, scan the chart using a flatbed scanner, and then create an ICC (International Color Consortium) profile.

ICC profiles are the information your input and output devices need to portray colors the same way. The reason you need these profiles is simple: Your monitor displays images using an RGB (red, green, and blue) system, while your inkjet printer uses a CMYK (cyan, magenta, yellow, and black) system to create prints. You can create custom profiles for your specific monitor, printer, and paper, and as a result, save money on consumables while creating dazzling printed photos.

Software considerations. It would have been misleading to tout a budget restriction in this story's headline but neglect to include software in the final price tag. After all, software costs as much (or much more) than hardware.

For still photo editing, we wanted to include Adobe Photoshop, but the $650 list price was too steep. Because it has most of the crucial capabilities from Photoshop and also a low learning curve, we selected Photoshop Elements 2.0.

We also wanted a video-editing application that would be easy enough for new users to learn and inexpensive enough to help keep our budget under control. We chose Pinnacle Systems' Studio 9. This program includes everything you need to organize, edit, and burn a final video to CD or DVD. Best of all, we managed to pick up Studio 9 for less than $100.

Cutting corners. We definitely cut a few corners to make all of these products fit under our budget cap. We spent almost nothing on our poor machine's case. As a result, we were prepared to deal with less-than-perfect construction, and we had to cross our fingers and hope that the Turbolink power supply would generate a smooth flow of electricity to our expensive components. Finally, though it was largely an afterthought, we purchased a 10-in-1 flash card reader to speed image transfers from our digital camera to the hard drive.

The Build

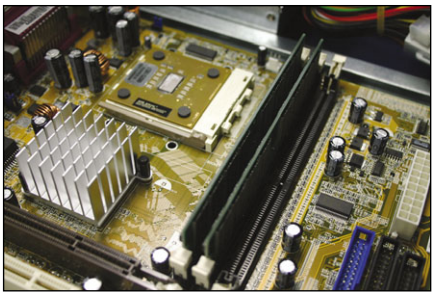
We lowered the motherboard into the case and confirmed that the case's motherboard port plate wouldn't work, so we dug out our ASUS plate and popped it into place. Then we twisted a few standoffs into the appropriate case holes and secured the motherboard with case screws.

After we locked down the CPU, we installed a Speeze heatsink/fan combo. This heatsink came with preapplied thermal grease, so all we had to do was affix it to the CPU socket's tabs, making sure that the raised edge of the heatsink hung over the raised plastic area of the socket.

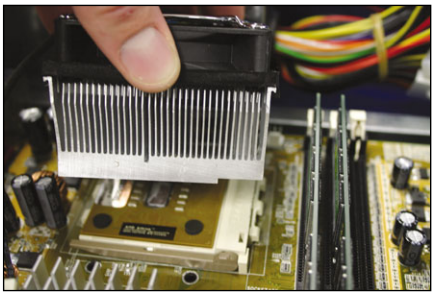
Our RAM modules went into the two slots closest to the CPU socket. After we locked these into place, we pushed our ATI video card into the AGP slot and locked it, as well. If you reverse these steps, be careful because the video card can push down and block the plastic locks that secure the RAM modules. After we inserted the video card, we pushed our FireWire card into an adjacent PCI card slot and secured it with a screw.

Next, we screwed our floppy, DVD, and hard drives into their case brackets. The floppy and hard drives were easy to install, but before we could insert the DVD drive, we had to pop off one of the plastic brackets covering the top 5.25-inch drive bay; we did this by carefully prying the bracket's plastic tabs from inside the case. Then, we pushed the drive into place and snapped the case's drive bracket back into its original slot.

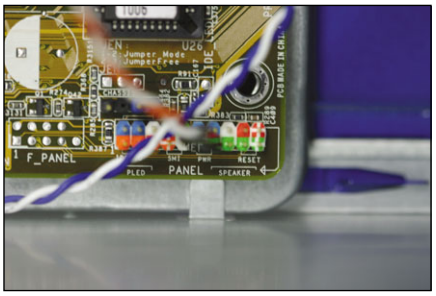
Then it was time for a little wiring. We took connectors from the power supply and plugged one each into the DVD and hard drives; we used the single smaller power connector for our floppy drive. We also connected a power cable to the edge



We inserted our RAM modules into the two slots closest to the CPU.



Make sure you install the heatsink with the raised edge hanging over the large plastic bulge on the CPU socket.



The Power and Reset button wires plug in to these connectors on the motherboard. The motherboard's manual contains diagrams that make it easy to connect each set of wires.

Our ATI video card was so long it threatened to block the plastic locks for our RAM modules. To avoid this problem, install your RAM first.

of our video card. Then, we plugged the large ATX power connector into the motherboard. To make sure our case's front-mounted power button worked, we plugged the Power SW wires onto the dark orange motherboard connector. The Reset wires went onto the connectors just to the right of the power switch. The ASUS manual's detailed diagrams included clear instructions for connecting other wiring, such as those for case LEDs.

Windows XP installation. Once we wrapped up our wiring, we closed up the case and pressed the Power button. Our machine immediately loaded the BIOS menu. To begin our WinXP installation, we had to change the boot order of the drives, so we used the arrow keys to select the Boot menu and then used the plus (+) and minus (-) keys to arrange our choices, which made the computer boot first to the optical drive, then the floppy drive, and finally the hard drive. We pressed F10 to save our changes and exit the menu, and then we inserted the WinXP installation CD.

The CD loaded to a blue screen, and we pressed F6 when the installation prompted us to load drivers for SCSI or RAID devices. We needed to load drivers for our SATA hard drive; otherwise the setup routine wouldn't be able to continue. After a short delay, setup prompted us to specify the drivers we wanted, so we pressed the *S* key and inserted a floppy disk containing our drivers.

Of course, before we could insert this disk, we had to create it; this was an easy process. On another computer, we inserted our ASUS driver diskette and ran a search for MakeDisk. By double-clicking this file, we launched a small program that automatically copies the drivers to a blank floppy diskette.

We inserted our driver diskette into our new PC and pressed the ENTER key. From the list of drivers, we selected VIA Serial ATA Controller (Windows XP) and VIA ATA/ATAPI Host Controller (Windows XP).

Then WinXP began walking us through other basic installation tasks. We created a single partition on the hard drive and formatted the drive using the NTFS Quick option. From there, WinXP installed its basic system files, and after we answered a few basic questions, our new PC was ready to go.

Testing

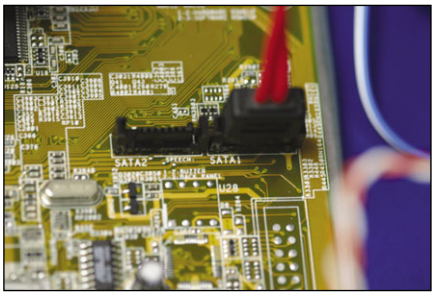
After WinXP completed its startup routine, we accessed the Control Panel and loaded the Device Manager. We found several yellow exclamation points screaming for drivers. We inserted our ASUS CD, right-clicked our Ethernet hardware, and then clicked Update Driver. WinXP automatically found several drivers, so we selected the English version (designated in the driver's pathname), and then our Ethernet capabilities sprang to life. We repeated these steps for our other components, including the video card and the multimedia audio controller.

Once we were done installing updated drivers, we noticed that our Start menu options were flickering as we browsed through installed programs. We definitely had a configuration problem of some kind, so we right-clicked the My Computer icon and clicked Properties. WinXP reported that our Athlon CPU was running at only 1GHz.

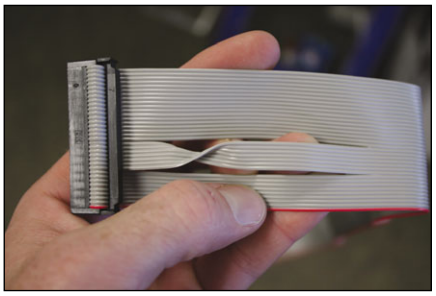
To fix this problem, we restarted the computer and pressed the DELETE key to enter the BIOS menu. On the Advanced menu, we selected the CPU Speed option and changed the speed to 2,100MHz. After we saved our changes, the computer started into WinXP again, and this time, we didn't notice any graphical hiccups.

We installed each of our programs and peripherals to make sure there were no conflicts. We didn't encounter problems with the installation or use of any products, and though digital video editing is often a troublesome activity, we didn't have any trouble transferring clips to our hard drive for an editing session.

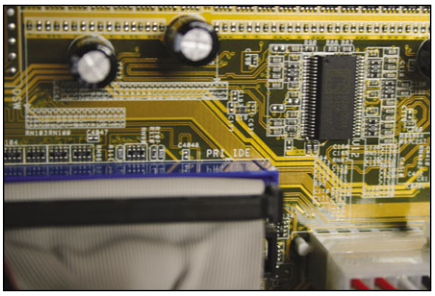
System Notes	
Height	17 inches
Width	7.8 inches
Depth	16.5 inches
Weight	20.54 lbs.
Features	
1GB RAM (can upgrade to 3GB, but only with DDR333)	
AGP 8X	
Six PCI slots	
Four rear USB 2.0 ports	
Reads 10 flash card formats	
Six-channel audio CODEC	
Two SATA connectors	
48-bit scanning	
Color calibration for printer	
Benchmarks	
PCMark 2004	5325
3DMark 2003	3506



Here's the connector for the SATA hard drive data cable. These connectors are keyed, so there's no way you can plug them in the wrong way.



The twisted end of the floppy drive cable goes into the back of the drive.



We plugged our DVD drive's IDE cable into the primary IDE connector on the motherboard. This connector is bright blue.

Then it was time to pit our new system against two benchmarking programs. We started with PCMark 2004, and after we ran each of this application's tests, we ended up with a final score of 3506. We also tried out our video capabilities using 3DMark03. Our final score here was 5325.

Profiles. One of the most challenging aspects of building this editing system was setting up the color-matching software and hardware. Because we aren't experts at building ICC profiles, we had to take extra time to make sure we did this process correctly. We started with our monitor.

For starters, we had to kill the lights. You can't accurately calibrate a monitor with light shining directly on the screen. We also had to make sure that Adobe Gamma wasn't one of our computer's startup programs, so we confirmed that the Gamma files weren't in our Windows Startup folder.

Then, we used the OptiCal software to calibrate our monitor and create a high-quality ICC monitor profile. To do so, we had to know how to tweak a few monitor options, such as contrast, brightness, color, temperature, and more. Most monitor manuals have instructions for such alterations. Using a step-by-step on-screen process, we answered a few basic questions about our monitor, affixed the Spyder to the screen, and let the products do their thing. At the end of the calibration process, we manually altered the luminance to fit within specific criteria that were touted as being best for color-critical applications.

Once we completed the calibration, the program instructed us not touch any monitor controls for fear of throwing off our new color balance scheme. The program also said that the calibration process should be performed every two weeks, as monitor colors tend to "drift" as they age.

ProfilerPLUS. To profile our printer, we used the ProfilerPLUS software included as part of our Spyder suite. Because we installed Photoshop Elements instead of Photoshop, we were able to create RGB profiles, but not CMYK profiles. In either case, it's a lot of work to develop and finalize profiles for a photo printer. After spending hours using this program and wasting plenty of ink and paper, we'd be happier using the stock profiles that Epson installs with the printer driver.

If you want to give it a shot, here's how to get started on your own profile. After launching Elements, from the Edit menu, click Color Settings and then select Full Color Management. From the File menu, point to Automation Tools and then click ProfilerPLUS RGB. Click OK to load the calibration chart.

From File menu, click Print Preview. At the bottom left, click the Show More Options checkbox. Set the Source Space to Same As Source or RGB Color and make sure the Print Space option is set to Same As Source. Then, print the chart and place it on your flatbed scanner.

From the File menu, point to Import and then select the CanoScan option. With the calibration chart file still open, from the File menu point to Automation Tools and then click ProfilerPLUS RGB.

From the drop down menu, select Build Profile. You can choose the High Precision option if you want to tweak color levels individually, or just choose the Normal option and click OK, and then give your profile an appropriate name. The next time you open Elements, your profile will appear in the Print Space profiles, and you can use it with any program that supports full-color management.

Because printer profiling is a detailed subject that takes practice, if you run into any problems, call company tech support or scan the friendly forums on Digital Photography Review (www.dpreview.com). Here, you'll see many more stories on the trials and tribulations of profiling and color calibration.

Final Remarks

Because of the frustration we encountered with the pro-level color profiling products in this story, we don't recommend them unless you're dead-set on nailing down the color characteristics of your system. That said, the cash we blew on these products would go a long way toward a much larger hard drive and possibly a bigger monitor.

You might consider other products, as well. We would have preferred a more solid case; even though the PSU didn't cause us any problems and was suitable for general use, the case itself was a bit on the flimsy side. And we could've done with a less expensive FireWire card, too, as the last-minute model we used pushed us over budget.

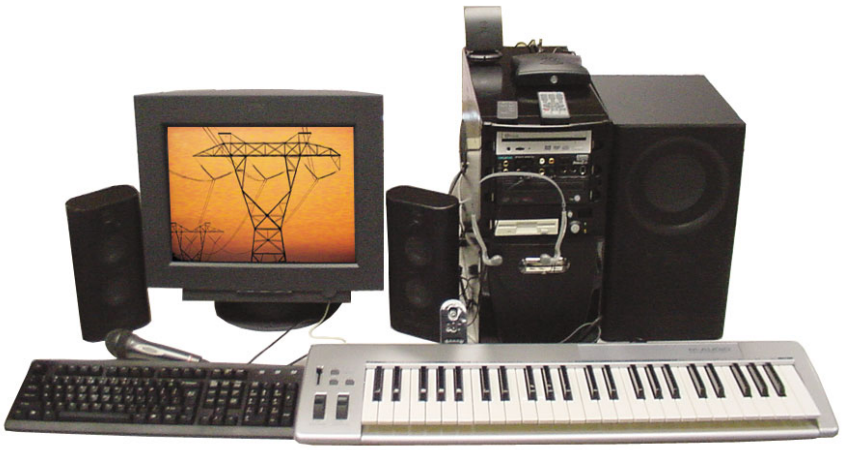
Our system's internal components, however, were up to the job. With a machine like this one, you won't experience the headaches that slower computers cause when confronted with the strains of digital imagery. RS

by Nathan Chandler

Best Audio Capturing, Editing & Burning System For Under $2,000

The Sound Station Of Your Dreams

Build #13 Skill Level: 1 **2** 3 4 5 *Apprentice*



Most basic prebuilt computers come with the necessary tools and resources to burn and rip music to the average users' satisfaction. However, true audiophiles want a system that lets them do much more with their audio files. Casual listeners, tune out.

Goal

This system will provide the basic tools for composing music, editing files, and playing back any and all kinds of audio at near-professional quality without costing nearly as much as professional audio equipment. We had a budget of $2,000, which gave us plenty of room for extra frills such as an XM Radio receiver, unidirectional microphone, and a 49-key MIDI keyboard. The centerpiece of this system is the Audigy2 ZS Platinum PCI sound card, which eats integrated audio chips for breakfast and sonically decimates other sound cards.

Background

Audio encoding can be extremely processor intensive, so we chose the powerful Athlon 64 2800+ for our CPU. We went to ASUS for our K8V SE Deluxe motherboard, which features enough peripheral connectors to keep us happy. 1GB of RAM was essential, so we went with a PC 3200 dual kit from Kingston. Our graphics were courtesy of the NVIDIA GeForce FX5200 Ultra video card. We priced the nonultra version for this system but ended up using an FX5200 Ultra we had on hand. The RAID capability of our VIA and Promise chipsets left us the option to implement an array, but for now we chose a single, ultra-quiet 160GB Samsung Serial ATA hard drive. 160GB will give us plenty of room for a multitude of beefy WAV file samples and loops. The integrated audio of our motherboard is unimportant because we are installing a standalone sound card in the form of Creative's Sound Blaster Audigy2 ZS Platinum, which includes a 5.25-inch internal input/output drive. It was our initial intent to exclude a floppy drive, but things didn't quite work out that way.

The Plextor PX-708A/SW optical drive served as our master drive, which lets us read and write multiple formats of CDs and DVDs. Our slave drive is a Samsung CD-RW/DVD-ROM with Noise Reduction technology. The dual CD drives will allow us to burn on-the-fly, as well as burn two projects at once.

When a manufacturer releases designs in a series, you know it's serious about its product. Our case is the Antec Sonata, a piano-black steel case from the LifeStyle Series. The Sonata comes with a dual fan 380W Antec TruePower PSU, which is very capable of supplying power to our various components. The case features front-panel audio and USB and FireWire ports. The Sonata also includes a colossal 120mm fan, which should cool our case with minimal noise output. Our VGA monitor is a recertified G78 17-inch CRT from IBM. We bought a generic PS/2 keyboard and mouse combo to free up as many USB ports as possible. Our speakers needed to be a cut above, so we chose the Altec Lansing MX5021 2.1 speaker set.

For the operating system, we decided to use Windows XP Home with Service Pack 1a, which adds USB 2.0 support. Roxio's Easy Media Creator 7 supplied our burning needs, while Orion Platinum version 5 gave us a music content creation suite.

We purchased an XM Radio PCR, which provides 120 channels of high-quality satellite radio for about $10 a month. Forget those cheap stick microphones; we opted for Sony's F-V320 dynamic microphone for more professional-sounding

Parts List

Item		Price
Case	ANTEC Life Style Black Case/380W Power Supply, Model SONATA	$99
Monitor	IBM G78 1280x1024 17-inch Flat Black Monitor (Recertified)	$90
Mouse	Optical Scroll Mouse	$5
Keyboard	Keyboard SK-700B	$4
Mainboard	ASUS K8V SE Deluxe	$123
CPU	AMD Athlon 64 2800+, 512KB L2 Cache, (fan and heatsink included)	$187
RAM	Kingston ValueRAM Dual Channel Kit 1G (512MBx2) DDR PC-3200	$181
Hard Drive	160 Gig SATA Samsung	$129
Floppy	Samsung FDD-S321B	$7
Optical #1	Plextor 8X DVD-RW/+RW Drive, Model PX-708A/SW	$141
Optical #2	Samsung Noise Reduction Combo Drive 52X/24X/52X/16X	$70
Video Card	Rosewill nVIDIA GeForce FX5200 Video Card	$60
Sound Card	Creative Sound Blaster Audigy2 ZS Platinum	$165
OS	Windows XP Home full OEM version	$64
Software	ROXIO Easy Media Creator 7	$76
	Orion Platinum 5	$299
Speakers	Altec Lansing MX5021 2.1 speakers	$119
Misc.	Sony F-V320 Uni-Directional Vocal Microphone with Built-In On/Off Switch	$20
	XM Radio's XM PCR	$50
	M-Audio 49-Key Entry-Level USB MIDI Controller, Model Keystation 49e	$85
Total		**$1,974**

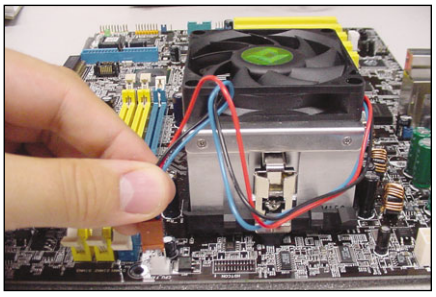
voice and acoustic instrument recording sessions. M-Audio's Keystation 49e was a reasonably inexpensive yet versatile MIDI keyboard.

The Build

We started by removing the side panel from our Sonata case (only one was removable). We inspected the front-panel and PSU connectors and then checked to make sure all the accessories and screws were included. At this point we removed the input/output plate that came with the case and replaced it with the one tailored to our motherboard. Whenever handling sensitive components, we made sure to release any static electricity by first touching a grounded piece of metal. We removed the motherboard from the protective plastic bag and laid it on the included piece of foam. We proceeded to check the various accessories and inspect the manual. When we were familiar with the motherboard and the manual, we examined the CPU.

While mounting our hardware to the motherboard, we made sure we were working on a clean, flat surface. The Athlon 64 2800+ PIB (Processor In a Box) included a stock heatsink and fan assembly. First, we lifted the K8V's socket-locking arm to a 90-degree (or open) position. The Athlon 64 processor has a small, gold triangle at one corner that corresponds to a triangle on the socket. We lined them up, and the processor slid in place with minimal force. Next, we locked the socket arm down.

The heatsink has a plastic sleeve that protects the preapplied patch of thermal paste. Our motherboard came with the retention frame and backplate already in place, but the Athlon 64's installation instructions detail the mounting process if your board isn't preassembled. We removed the plastic cover that protects the thermal paste patch and positioned the heatsink over the processor. After checking to make sure the cam lever was in the unlocked position, we lined up the metal spring clips on the heatsink with the plastic mounting lugs of the retention frame. By pressing on the metal spring clip just below the cam lever, we locked the heatsink into place. Next, we pressed on the opposite spring clip until it locked to the retention frame on the opposite side. Make sure to only apply pressure to the metal spring clips rather than the fan assembly. With the heatsink installed, we turned the cam lever and locked it into position as per the instructions. Finally, we plugged the CPU fan plug into the header labeled CPU_FAN.

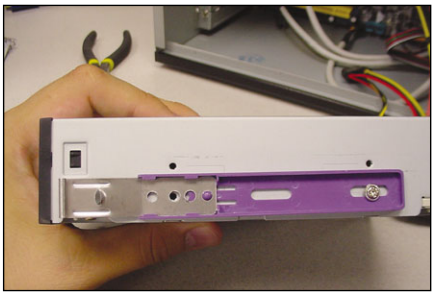


We plugged the heatsink fan into the labeled header on the motherboard.

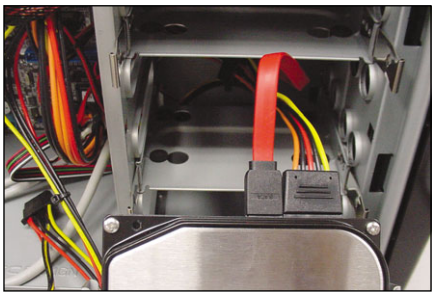
The K8V's manual details memory configurations specific to the amount and type of system memory we planned to install. Again, we made sure we were grounded and positioned the first stick of PC3200 RAM in the blue slot labeled DIMM 1. The memory module is notched so that it only fits into the slot one way. With the ejector tabs open, we pushed the module into place, one edge at a time, until the tabs locked the module down. We followed the same procedure for the second module, using the yellow slot labeled DIMM 2.

Next, we installed the standoffs in the appropriate holes for our K8V and screwed the motherboard to the case. The interior of our Antec case seemed tight, but we had very little difficulty getting the motherboard positioned and secured. We supplied power to the motherboard with both the 4-pin auxiliary connector and 20-pin ATX power connector. Our next task was to connect the system panel connector, which consists of the case's power switch, reset switch, IDE and power LEDs, and internal speaker. We checked the motherboard manual's diagram and matched the leads with the

Special screws and rubber grommets mounted the hard drive to the tray.



Rails made it easy to install and remove our various drives.



We threaded the hard drive cables from behind the drive.

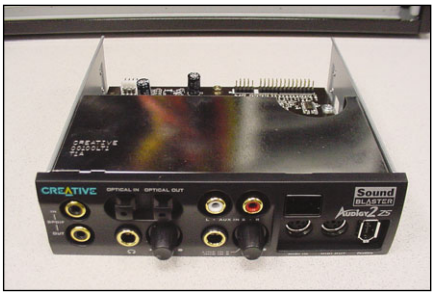
We connected the digital audio port from the master optical drive to the sound card.

labeled plugs, all the while keeping the plug labels facing outward. Next, we connected the front-panel USB and FireWire cables to the corresponding headers on the motherboard. Our front-panel audio ports came with a single plug that conforms to Intel's audio connector standard, so we just connected the plug to the audio header on the motherboard. The rear exhaust fan uses a standard Molex plug, so we connected it to the PSU with a plug labeled FAN ONLY. Finally, we connected the PSU fan plug to the header on the motherboard labeled PWR_FAN.

The internal 3.5-inch drive bays of our Sonata case consisted of slots and trays. We were able to remove the second tray from the top by squeezing the release clips on either side. The case included special screws that we used to secure the hard drive to the tray through rubber grommets. Next, we connected the power and the SATA cable. In an attempt to reduce cable clutter, we threaded the cables in from behind the drive. We connected the SATA cable to the VIA-controlled port on the motherboard labeled SATA1. Next, we removed all three drive bay covers and installed the drive rails on our two optical drives and the Audigy2 ZS Platinum's input/output drive. Before installing the drives, we set the jumper on the back of the Plextor drive to designate it as the master drive. By default, the Samsung drive became our slave. We also applied a jumper shunt to the leads marked JP1 on the Audigy2's drive, which configures the mic input for our dynamic microphone (rather than for a condenser microphone). We slid the Plextor drive into the top 5.25-inch drive bay, the Audigy drive into the second bay, and the Samsung drive into the bottom bay. The three drives need power, so we supplied them with the proper power plugs from the PSU. We used a ribbon cable to connect the two optical drives to the motherboard plug labeled PRI_IDE. The ribbon cable that came with the Audigy2 ZS Platinum looks like a normal IDE cable but is designed to fit only the leads on the drive and sound card. We suggest plugging this cable, along with the FireWire cable, into the drive's headers prior to the drive installation.

Our next task was to install our GeForce FX5200 Ultra. We started by removing the PCI bracket that lined up with our AGP slot. With the lock on the AGP slot open, we slid the card in place and locked it down and then screwed the bracket to the case. We supplied power to the video card with a Molex connector from the PSU. The Audigy2 ZS sound card went in next in the slot labeled PCI2. When the card's bracket was secured to our case, we plugged in the ribbon cable from the Audigy2 ZS drive. Next, we used the supplied digital audio connector to join the Plextor drive's SPDIF plug to the digital audio port on the sound card. Because our MIDI keyboard uses a USB port, we didn't bother to install the joystick/MIDI bracket.

Finally, we connected our monitor to the VGA port on the video card, the mouse and keyboard to the PS/2 ports, and the Altec Lansing 2.1 speakers to the green audio port from the sound card. We then turned on the monitor to let it warm up.



Here's the internal input/output Audigy2 ZS Platinum drive we installed.

Testing

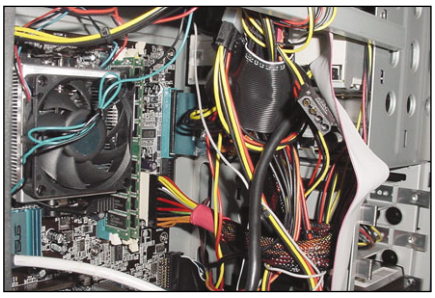
With our system assembled, we confidently pressed the power button. The first screen we saw displayed the American Megatrends logo and said, "New CPU is inserted in system!" We were given the option to press F1 to run setup or press F2 to load default values and continue. We wanted to examine our BIOS configuration before continuing, so we pressed F1 to run setup. In the BIOS Configuration Utility, we set the correct date and time and checked to see if the system had detected our optical drives. Next, we put the WinXP disc into our Plextor drive. Then, we checked the Boot tab and set the boot device priority so that the

The floppy drive was a reluctant, last-minute addition.

System Notes	
Outstanding Features	This system features a powerful processor, plenty of RAM, tons of hard drive space, a plethora of peripheral connectors (four FireWire; six USB 2.0), a high-end sound card, and enough extras to keep the audio enthusiast happy.
Weak Links	Despite the respectable speakers, this system isn't taking advantage of the Audigy's surround-sound capabilities. Studio quality headphones are also missing from our formula.

system tries the Plextor drive before the hard drive. We pressed F10 to save the BIOS settings and reboot. This time the system booted to a screen that told us to press any key to boot from CD-ROM, so we did. Next, the blue Windows Setup screen appeared, and our system began to load files from the disc. When prompted, we pressed ENTER to set up WinXP. An instant later we were informed that "Setup did not find any hard disk drives installed in your computer" and then told to press F3 to quit. As we had suspected, the floppy drive was a necessity in order to get our Serial ATA drivers loaded.

The air in our case had barely gotten stale before we opened it again to install the floppy drive. We removed the 3.5-inch drive cage and secured our floppy drive with four screws. We snapped the cage back into our case and connected the floppy ribbon cable to the drive and floppy port on the motherboard (making sure to line up the red side of the cable with pin 1 of each port). Next, we powered the drive with a plug from the PSU. At a working computer, we explored the motherboard support CD and double-clicked the Drivers folder. We double-clicked the VIARAID folder, double-clicked the 6420RAID folder, and then double-clicked the DriverDisk folder. We made sure we had a blank floppy in our computer's 3.5-inch drive and then double-clicked the MakeDisk file, which loaded the necessary files onto our floppy.



Our cable-management skills were overtaxed on this project.

With the WinXP Home disc in our new system's optical drive, we booted our computer and waited for the opportunity to press DELETE to access the BIOS Setup Utility. Under the Boot tab, we made sure the optical drive was our first boot device. We then pressed F10 to exit and save the changes. With the system powered up, again we were prompted to press any key to boot from the CD-ROM drive. We pressed ENTER and then, when prompted, pressed F6 to indicate that we wanted to install a third-party SCSI device. The next screen displayed the message, "Setup Could Not Determine The Type Of One Or More Mass Storage Devices." At this point, we pressed *S* to specify an additional SCSI adapter. When prompted, we inserted the disk and pressed ENTER. We then selected the VIA Serial ATA RAID Controller (Windows XP) option from the list of drivers.

The next screen we saw indicated that Setup had recognized the hard drive, so we pressed ENTER to continue. Then we pressed ENTER to set up WinXP. We chose to install WinXP on the partitioned space and pressed ENTER. This brought us to a screen that indicated that we were attempting to install WinXP in a partition that already had an operating system. Because we had used the hard drive in a previous system and were not concerned with retaining any of the old information on the drive, we pressed *C* to continue. On the next screen, we pressed *F* to format the drive. Once our drive was formatted, we were prompted to remove the floppy disk and reboot the system.

When the system restarted, we saw the WinXP Home loading screen, followed by the language options screen and the name and company screen. After entering the license key, we were asked to name the computer, update the time and date information, and then configure our network settings. We proceeded to load the drivers for our video and sound cards after which we were told to reboot, so we did.

With Windows up and running again and our audio/video drivers installed, we proceeded to set up our MIDI keyboard. We started by inserting the drivers disc into the master optical drive, which set up the system and prompted us to plug the keyboard in a few moments later. Next, we installed Roxio Easy Media Creator 7. Then we installed Orion Platinum, the content creation suite. In no time we were arranging our own compositions, recording audio, sampling music, and burning discs (all copyrights respected, of course).

Final Remarks

If you have no interest in a MIDI device, you may want to splurge on some studio-quality headphones. You may also want a set of surround-sound speakers to complement the Audigy2 ZS Platinum's eight-channel capabilities. A system for audiophiles could easily consume twice the budget we were given, but this system serves as a basic model of what worked for us. Then again, if you're serious about audio, you already know what components you can't live without. Happy listening. RS

by Andrew Leibman

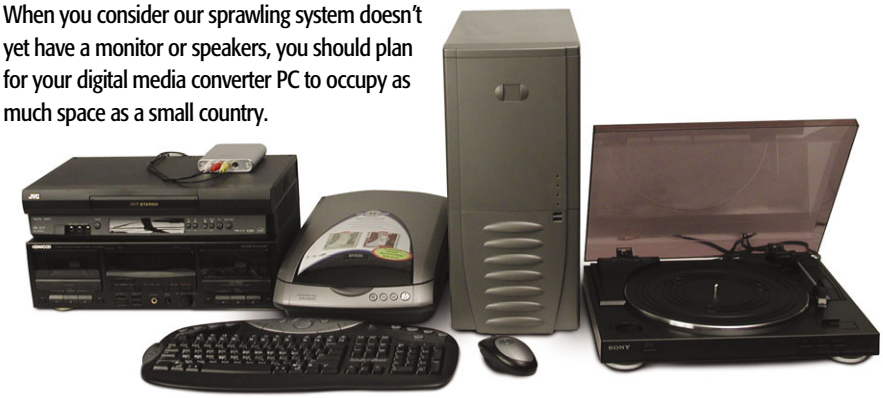
We're ready to capture, edit, and burn the night away.

Best Media Converter PC Under $1,500

Elvis (Records) Isn't Dead Yet

Build #14 Skill Level: 1 2 **3** 4 5 ***Journeyman***

When you consider our sprawling system doesn't yet have a monitor or speakers, you should plan for your digital media converter PC to occupy as much space as a small country.



In the good old days, your record collection was cool. Encompassing an eclectic assembly of bands from ABBA to ZZ Top, you were the king of LPs. Now, that collection is collecting dust in its designated basement cranny. With a little time and the right technology, you can keep your collection on your computer and peddle the vinyl at your next garage sale.

Goal

We didn't need to archive said legendary record compilation, but we did want to build a PC that could have. In fact, we set out with $1,500 to build a versatile system that could convert a variety of old media from analog to digital.

Background

With our goal in mind, we tried to strike a balance between the quantity of media formats and the quality of the hardware necessary to convert such media. For example, we could have spent $1,500 on a scanner and photo-editing software. On the other hand, we also didn't want to build a low-end PC that would undoubtedly lead to long conversion times and poor playback.

We should also point out that we weren't doing any digital mastering; for example, using Plextor's ConvertX hardware will let you transfer a VHS movie onto a DVD, but it won't actually make the movie DVD quality.

We also built this system from the ground up, assuming we had lots of old media lying around without a compatible player. As a result, we purchased a Sony PS-LX250H Fully-Automatic Turntable for $80, JVC's TD-W254BK cassette deck for $135, and a JVC HR-J692U VCR for $68. These would play our LPs, cassette tapes, and VHS tapes, respectively. In reality, you probably have a player for the media you want to convert; make sure your converter hardware has appropriate inputs. In our build, each player had RCA outputs.

For audio conversion, we relied on Creative Labs' Sound Blaster Audigy 2 ZS Platinum, which features a plethora of legacy inputs for $166. It also packs hardware-accelerated features, so our system itself would probably be less taxed during audio conversions.

Plextor, known for its DVD burners, also produces the ConvertX line of video convertors. We really liked its PX-M402U model because it can encode video in real-time in four formats: DivX, MPEG-4, MPEG-2/DVD, and MPEG-1/VCD. The MPEG-4 format is especially handy because its quality is almost as good as MPEG-2, but it's compressed to about 1/11th the size.

Although it was a tough decision, we opted for Plextor's PX-AV100U. At $79.99, it's about $100 cheaper than the PX-M402U, but it only encodes MPEG-1 and MPEG-2 in real-time. It uses software to encode in DivX (also a compressed file format) and doesn't encode in MPEG-4. If you must have MPEG-4 encoding, stick with the PX-M402U. Otherwise, the PX-AV100U's DivX encoding will be able to compress video files to a smaller size.

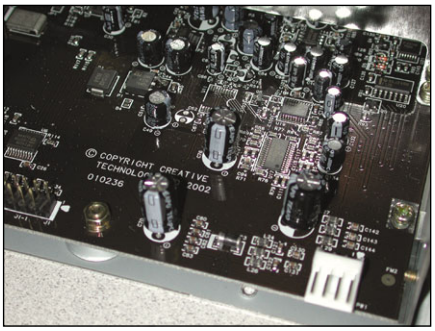
Because we were using separate hardware to convert video, we didn't need inputs on our video card or a separate video capture card. At the same time, our graphics card needed to be good enough to play DVDs without skipping. We spent $100 on a Sapphire Radeon 9600 graphics card with 256MB RAM. If you decide to skip a converter such as Plextor's ConvertX, you'll need an all-in-one video card or a video capture card to convert your videos.

We should briefly mention we looked for equipment to digitally convert 8mm, but the necessary equipment is priced for professionals only. We recommend using a third party to convert 8mm film.

There were a lot of choices to convert our analog photos. The three scanner giants—Canon, Epson, and HP—have fairly comparable scanners, but pay extra attention to your scanner's resolution. Many manufacturers will advertise both optical and digital resolution. A scanner's optical resolution relates to its hardware capabilities, but its digital resolution refers to resolution achieved through software manipulation. Therefore, a scanner's optical resolution is a more accurate representation of its "true" resolution. Be wary of any scanner that lists only one high resolution as it's it's probably a digital resolution. We picked the Epson Perfection 3170

When we attached the runners to our NEC DVD±RW drive, we used the top hole on the runners and the bottom side holes on the drive.

Although the Platinum drive has composite and digital audio inputs, there's also SPDIF, MIDI, and FireWire inputs that aren't pictured.



We used extra care to avoid damaging the Platinum drive's capacitors when we connected its cables.

Parts List			
Hardware			
Case	Antec Solution Series Mid Tower Case	$47	
Power Supply	350W Antec PSU	$0	Included with case
Motherboard	MSI 865PE Neo 2	$123	
Processor	Intel 2.8GHzC Pentium 4	$178	
Memory	512 Kingston Value RAM	$83	
Hard Drive	Western Digital SATA Hard Drive*	$129	OEM
Video Card	Sapphire 256MB Radeon 9600	$100	
Sound Card	Sound Blaster Audigy ZS 2 Platinum	$166	
Network Card	Integrated into motherboard	$0	
CD Drive	See DVD±RW Drive	$0	
DVD-ROM /CD-RW Drive	See DVD±RW Drive	$0	
DVD±RW Drive	NEC Dual Layer DVD±RW Drive	$87	OEM; After $40 mail-in rebate
Monitor	none	$0	
Speakers	none	$0	
Keyboard	Belkin Wireless Keyboard**	$32	
Mouse	Included with keyboard	$0	
Scanner	Epson Perfection 3170	$169	
Video Capture Device	Plextor ConvertX PX-AV100U	$79	
Media Players			
VCR	JVC HR-J692U	$68	
Turntable	Sony PS-LX250H Fully Automatic Turntable	$80	
Cassette Deck	JVC TD-W254BK	$135	
Software			
OS	Windows XP Home	$64	On sale; Clearing out SP1 before SP2 release
Total		$1,540	

**250GB Western Digital SATA hard drive used instead*
*** Logitech Wireless Keyboard/Mouse Combo used instead*

PHOTO for $169, which also included 35mm film and slide adapters.

High-capacity storage devices were a must for this system. We had initially picked a 200GB Western Digital SATA hard drive for its capacity and fast data transfer rates, but we actually used a 250GB Western Digital drive because we had an extra one from an old build. 250GB is an awesome amount of space, but a lot of video files will quickly gobble it up.

We then selected NEC's dual-layer DVD±RW optical drive to complement our hard drive. The dual-layer technology allowed us to record twice as much data on compatible DVD recordable discs. Between the 250GB Western Digital hard drive and the NEC DVD burner, which cost $129 and $87, respectively, our storage capacity would be limited only by our budget.

Because we had hardware specifically designed to shoulder some of the converting load, we didn't use a high-end CPU or load up on memory for our system. We selected an Intel Pentium 4 2.8GHz processor with 800MHz FSB and Northwood core ($178) and 512MB of Kingston PC3200 Value RAM ($83). MSI's Neo2-PFISR mobo supported the P4's 800MHz FSB and had very flexible DIMMs. The mobo also has room for another SATA drive and three additional IDE devices, so you'll have plenty of extra room for additional hard drives. And at $123, it's not the most expensive board.

Here are a few quick notes before we get down to the build: Our system lacks two obvious things you'll want to include in your system: a monitor and speakers. We

used a spare monitor and sound system we had lying around, but your final cost will likely be similar if you consider you probably won't have to buy old media players.

The Build

Aside from rustling up a 3.5-inch floppy drive to install our SATA drives, adjusting some BIOS settings, and spending the better part of an hour trying to fit our DVD burner into a 5.25-inch bay, building this PC wasn't too difficult. We laid a hard plastic floor mat over our carpeted floor and touched the metal chassis on our case to reduce static electricity before the build.

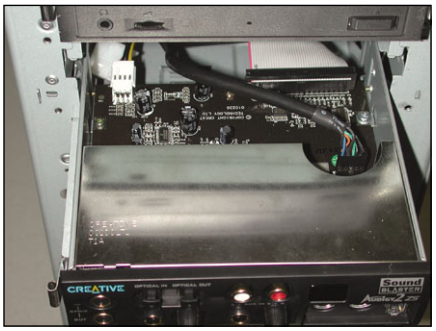
We did have to make a few changes to our CPU fan mount. When MSI designed this particular mobo, they must have thought it would be fun to put a row of capacitors right next to the CPU fan-mounting bracket. As a result, the CPU fan's mounting clips rubbed up against one of the capacitors. After we sliced off a few slivers of plastic off the fan assembly with our trusty Swiss Army knife, it fit perfectly.

Installing the graphics card was simple, but we should note that its heatsink effectively eliminates one of your PCI expansion slots. Because we couldn't use the PCI slot immediately below the AGP slot, we used its corresponding opening on the case to mount our mobo's FireWire ports.

Call it a lapse in cerebral activity, but our installation of our DVD burner easily resembled a "How many . . . does it take to screw in a light bulb?" joke. When we tried to slide the drive into an open bay, the mounting clips made the drive too wide to fit. Solution: Remove the front of the case.

We learned our lesson with our NEC DVD burner and installed the Sound Blaster Audigy 2 ZS Platinum with ease. The Platinum drive that is included with the card itself mounts in a front 5.25-inch bay, and we left an open bay between the Platinum drive and the DVD burner because we had to connect the Platinum drive to the sound card with AD_EXT and FireWire cables. Be careful with the AD_EXT cable: It looks like IDE ribbon cable, but the two are not interchangeable.

Before beginning the WinXP installation, we changed a few BIOS settings on our system once we were at the BIOS main



You might want to connect the Platinum Drive's cables before completely inserting it into the 5.25-inch bay.

menu (press DELETE during the computer's initial boot). First, we went to Integrated Peripherals, On-Chip IDE Configuration, ATA Configuration and changed the setting to PATA and SATA. While we were still in the On-Chip IDE Configuration menu, we went to Combined Mode Option and set it to 1st Channel PATA. We returned to the main menu and went to Advanced Bios Settings. We set our boot device order to the following: floppy first, CD/DVD-ROM second, hard drive third. We pressed F10 to save our changes and exit the BIOS.

We used a spare 3.5-inch floppy drive for the sole purpose of installing our SATA drivers, but you'll need to factor that cost into your build if you don't have one. WinXP doesn't include SATA drivers, so it won't recognize a SATA hard drive if you don't install third party drivers. Usually, these are included on a floppy disk that is packaged with your mobo, but you might need to download drivers and copy them onto a floppy disk of your own. To install the SATA drivers on a fresh WinXP setup, we pressed F6 when prompted during the first 30 seconds of the installation. Although the prompt only mentions SCSI and RAID drive, SATA falls under this umbrella. Our WinXP installation was problem-free once we installed the SATA drivers.

After WinXP successfully started, we installed our remaining drivers and software applications and connected our peripherals. The scanner comes with both USB 1.1 and 2.0 cables, so you'll want to use the 2.0 cable if you have the ports to match. The ConvertX requires a USB 2.0 port.

We hooked up our VCR, cassette deck, and turntable and were ready to let our VHS tapes, cassettes, and LPs live again in a brave new digital world. Hold onto your hat, Mr. Huxley.

Testing

We committed the bulk of our time to testing the limits of the software included with our various peripherals. If our software was wimpy enough to warrant purchasing third-party editing software, we wanted to know. On the other hand, we didn't want to neglect benchmarks, either. In case you're curious, our rig scored 2482 in 3DMark03 and 3618 in PCMark04.

For our first test, we put the ConvertX through its paces by converting an old copy of the Chris Farley epic comedy "Tommy Boy." We ran RCA cables from our VCR to the ConvertX, which also has an S-Video input, and opened Intervideo's WinDVD Creator 2 software. We clicked the large record button (it's a circle with a smaller red circle in the middle) and pressed Play on our VCR.

Overall, we thought the ConvertX did a great job capturing video. When we replayed the video, we didn't notice any hang-ups or skips. The video quality was far from something we'd expect to see on a DVD, but remember the ConvertX doesn't digitally master the media; it simply converts it.

Pushing The CPU To Its Limits

The ConvertX users manual warns not to overburden the CPU during video capture, but we paid no heed to this caveat and played a quick game of Unreal Tournament 2004 at its default settings during a video capture session. While we thoroughly enjoyed UT 2004 and only experienced a few minor hang-ups, our captured video told a different story. The video became progressively choppier and slowed to a standstill. We certainly agree with Plextor and recommend that you resist the urge to perform other CPU-intensive tasks while you're capturing video. Start capturing video, set a timer, and finally get out and mow that lawn.

We had more success performing other tasks during audio conversion. First, we

System Notes	
Physical Description	
Height	18.3 inches; 44.5cm
Width	8.25 inches; 21cm
Depth	18.6 inches; 47.2cm
Form Factor	ATX
System Specs	
Motherboard	Supports Intel Pentium 4 processors (Northwood/Prescott cores); Intel 865PE + ICH5R; Supports FSB 800/533/400 (Northwood only) MHz; Four Dual Channel DIMM Slots; 2x SATA (RAID 0/1);SATA (RAID 0/1); 2x ATA 100 up to four devices; 8 USB 2.0 ports; Six-channel integrated audio; 10/100/1000Mbps integrated LAN
CPU	Intel 2.8GHz Pentium 4 (Northwood), 800MHz FSB
Memory	512MB PC3200 RAM
Hard Drive	200GB SATA hard drive, 7,200rpm*
Video Card	256MB Radeon 9600
Scanner Optical Resolution	3200 x 6400 dpi
Software Highlights	Windows XP Home SP1
Performance	
3DMark03	2482
PCMark04	3618
Outstanding Feature	Very easy to use and produces results most people will be pleased with; giant hard drive will store large, high-quality video files
Weakest Link	Power users may demand better editing software
Summary Remarks	It's easy to forget this rig is a great midrange system even if you don't use it to convert old media. This is the perfect system to archive your photo album or record collection.
**250GB SATA hard drive, 7,200rpm used instead*	

connected our Sony turntable's RCA outputs to the Sound Blaster Audigy 2 ZS Platinum Drive's Auxiliary In 2 inputs. Although we used Creative MediaSource to convert audio, it's not the only recording app included in the software bundle. We clicked Start, All Programs, Creative, Creative MediaSource, and Creative MediaSource Player. We clicked the small upside-down red triangle and Select Recording Source and selected Auxiliary 2 as our recording device. We clicked the record button and started our turntable. The only imperfections we could detect were small blips from the LP's imperfections, and Creative WaveStudio can iron these out.

Because we stored our converted files on our hard drive, we selected the highest possible bit rate—320Kbps—well above CD quality. If you're planning on burning songs to a CD, you'll need to reduce the bit rate of your files in order to record more than a handful of songs onto a CD-R. (You probably already know this, but WAV files, the most common format compatible with CD players, are far larger than MP3s.) You can probably leave the bit rate high if your CD player also plays MP3s.

We had hardly let our CPU catch its breath when we fired up UT 2004 while Creative MediaSource converted a portion of an LP to MP3; even though our CPU was under a heavier load, the results impressed us. In order to capture audio from the turntable and hear game sounds, we clicked Start, Programs, Creative, Sound Blaster Audigy 2 ZS, and Creative Surround Mixer. We clicked the Auxiliary In 2's speaker button to mute the turntable. (Just because you can't hear sound doesn't mean the Sound Blaster Audigy 2 ZS Platinum isn't recording it.) When we were playing UT 2004, we didn't notice any unusual hang-ups and were surprised to find our MP3 turned out exactly as it did when our CPU wasn't under a heavy load.

If you prefer leaving your media converter PC alone while you tackle other tasks, you can break a single-track album into individual tracks using Creative WaveStudio. We needed to do this anyway because our automatic turntable would only start at the beginning of an album.

Scan This

We had successfully converted a VHS tape, LP, and cassette tape and were ready to wrap up our testing with the Epson Perfection 3170. Some may be disappointed that the Perfection 3170 only includes plastic adapters to set negatives and slides in, and you may want to invest in a separate negative or slide scanner if these formats constitute the bulk of your scanning.

Connecting the turntable or cassette deck is as easy plugging the RCA cables into the Platinum Drive.

All things considered, the Perfection 3170 performed well. Epson's Color Restoration did a remarkable job adding new life to some of our photos, but the results were less dramatic on others. Epson doesn't include much photo-editing software; even an application such as Adobe Photoshop Elements or Roxio PhotoSuite will give you a few more editing options. Again this is a solid midrange scanner, but it's a few steps below a professional-grade scanner if you'd rather blow your budget on lots of photo-editing goodies.

Final Remarks

Some might scoff at this system's price tag, and we admit you *can* convert each individual media for much less than $1,500. For instance, you can turn your existing PC into a media converter system by simply adding the particular peripheral you need.

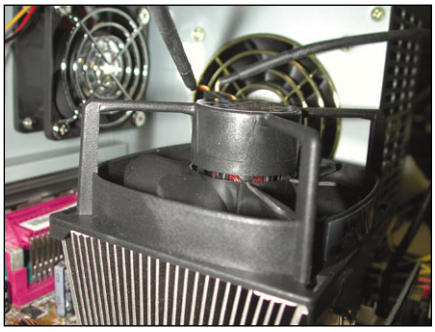
On the other hand, our rig converts a variety of old media formats and is a decent system for other computing tasks. While we didn't include a monitor or speakers in the cost, we also spent money on a turntable, cassette deck, and VCR—all items you're likely to own. If you need a new computer and want to convert your old media, this is one neat way to do it. RS

by Vince Cogley

Best DVR Under $1,000

MythTV: The Stuff Legends Are Made From

Build #15 Skill Level: 1 2 3 4 5 *Grandmaster*



Our Artic Cooling heatsink should provide better performance than AMD's stock heatsinks, and our power supply will provide additional cooling. We didn't connect our case fan and didn't notice much of a problem with heat.

While DVRs (digital video recorders) such as TiVo and ReplayTV aren't as commonplace as the VCR, early adopters who do own one quickly become enamored with them. It's not just the ability to create your own instant replays or pause live TV when a friend calls, it's the ability to easily find and record your favorite shows.

Anyone can buy a DVR from his local electronics store, but what fun is that? We're a country of builders. Benjamin Franklin wouldn't have been happy with an off-the-shelf TiVo. Oh, no! He would've rolled up his sleeves and built a DVR with his own two hands. With the spirit of our forefathers in our hearts, we set out on a grand adventure to build our own DVR from scratch.

Goal

Our goal for this project was to build a TiVo-style DVR for less than $1,000. We wanted something that would let us easily schedule recordings, connect to our television set and surround-sound receiver, and fit in visually with our other A/V components. Because we plan on connecting the system to a television, we didn't figure a monitor into our budget, but you'll need to borrow a monitor to configure the system.

Background

We began our project planning by picking software for our system. Windows XP Media Center Edition is impossible to find at retail, so we quickly scratched it off our list. A number of alternatives that run under Windows are available, but we wanted to spend our money on hardware and features, not software.

We eventually decided on MythTV. For those who are unfamiliar with MythTV, it is open-source software that runs on Linux. Like any DVR software, MythTV lets you pause and rewind live TV or schedule programs for future recording.

In order for the system to fit with other home theater components, we needed a desktop-style case. We settled on a Silverstone SST-LC03 for $138. The case features a silver finish, drive bay doors to hide the optical drive, and nice blue LEDs to accent the case. Unfortunately, the case only has one 60mm case fan mounted next to the power supply. This might make the system run a little hot.

The case didn't come with a power supply, so we spent an additional $42 on a Thermaltake W0007R Silent 360W PSU. The PSU is relatively silent so as not to interfere with our television enjoyment.

Once we had the case, we could concentrate on a processor and motherboard. We decided on an AMD Athlon XP 2600, which is inexpensive at $85 and well supported by motherboard manufacturers (meaning we'll be able to find an inexpensive board to match). We don't need a lot of processing power because we're going to invest more in our video capture card. We ordered the processor OEM, so we spent an additional $13.99 on an Artic Cooling Copper Silent heatsink. The heatsink should provide better cooling than AMD's stock heatsink without making too much noise. It includes a switch to adjust the fan's speed, but even on high the fan is relatively quiet.

We picked out an ASUS A7V600-X motherboard to accompany our processor. The motherboard supports SATA hard drives in addition to standard IDE drives. For memory, we settled on 256MB of PC3200 DDR SDRAM. PC2700 would be plenty fast for this system, but we just happened

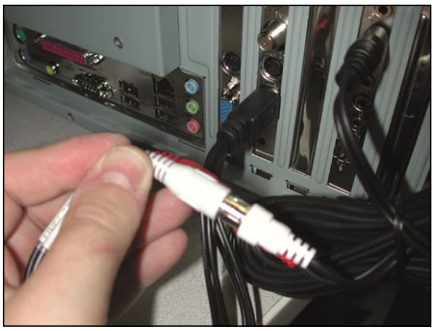
Parts List

Component	Model	Price
Case	Silverstone SST-LC03	$138
Motherboard	ASUS A7V600-X	$67
Processor	Athlon XP 2600+ (Barton)	$85
Memory	Simple Tech 256MB PC3200	$45
Hard Drive	Maxtor DiamondMax 16 80GB IDE Hard Drive	$71.99
Video Card	Apollo S3 Savage IX	$14.50
Video Capture Card	HAUPPAUGE WinTV PVR 350	$189.99
Sound Card	SoundBlaster Audigy 2 ZS	$88
Network Card	Integrated	$0
DVD Writer	NEC 8X DVD±RW ND-2500A	$69.99
Mouse & Keyboard	Belkin Wireless Keyboard & Mouse	$32
OS	KnoppMyth	$0
	USB-UIRT IR Blaster*	$49.99
	D-Link AirPlus ExtremeG*	$59
Total		**$910.46**

** Extra components to add functionality*

Our system's case is a little bigger than we wanted originally, but it should still go well with our A/V components.

System Notes	
Operating System	KnoppMyth (Linux)
Processor	Athlon XP 2600+
RAM	256MB PC3200
Bus Speed	333MHz
Hard Drive	80GB IDE
Optical Drive	DVD±RW
Connectivity	10/100 Ethernet
Video Card	Apollo Savage IX
	& Hauppauge
	WinTV PVR 350
Video RAM	8MB
Sound Card/Speakers	Soundblaster
	Audigy 2 ZS
Chassis Size (inches)	6.3 x 16.7 x 16
Weight	26.36 lbs



Connect the audio-out cables from the DVR-350 card to an RCA-to-miniplug cable. Connect the miniplug to the line-in jack on the Audigy 2 ZS.

to have some spare PC3200 on hand. We don't need a lot of memory for our configuration, so one 256MB memory module should be fine.

The video capture card is an important consideration. We settled on the WinTV DVR-350 from Hauppauge. The DVR-350's greatest asset is its integrated encoder and decoder. This takes a great deal of pressure off the processor and lets us get away with a less expensive processor. The video capture card includes its own remote control. We paired our video capture card with a SoundBlaster Audigy 2 ZS sound card. The Audigy will connect nicely to a 5.1, 6.1, or 7.1 surround-sound system.

The DVR-350 is a TV capture card that includes TV Out, but we'll still need a video card in order to install and configure our software. We found a $14.50 Apollo S3 Savage IX video adapter that works nicely.

And, of course, any DVR needs storage. We started off with a SATA drive but later moved to an 80GB IDE hard drive. The drive is a little on the small side, but you can always add an additional drive later on. We also wanted to include a DVD burner with our system for burning our video clips to DVD (which isn't officially supported in our software but possible nonetheless). We used an 8X NEC drive that supports both DVD+RW and DVD-RW. We found a drive with a silver finish to match our case.

Finally, we needed a keyboard and mouse. We purchased a Belkin wireless keyboard and mouse. The mouse isn't optical, but the set was inexpensive and MythTV doesn't support a mouse anyway.

The Build

Normally, installing the hardware is the most difficult part of building a system. Not so this time around. In order to cover the more complex issues of software configuration, we'll spend just a little time talking about the physical build.

There are very few DVR-specific installation steps. Once the guts of the system were together, we connected the output cable to our WinTV DVR-350 and connected the red and white audio outputs to an RCA-to-miniplug cable (a cable with two RCA inputs on one end and a miniplug on the other). The miniplug connected to the Line In on the back of the Audigy 2 ZS. Next, we connected the IR receiver to the back of the WinTV DVR-350 and strung it around to the front of the system. We connected our coaxial cable input Ethernet cable and wireless keyboard and mouse receiver to the system. Finally, we connected our monitor to the video card and our television to the video out cable on the DVR-350.

Installing MythTV. KnoppMyth is a small Linux distribution (roughly 500MB) that includes all the software you'll need for a working MythTV configuration. Although it's not the only way to install and configure MythTV, it's by far the easiest.

We started by downloading the latest version of KnoppMyth (R4V4.1) from www.mysettopbox.tv and burning it to a CD. You'll need software for your burner that can handle ISO image files. ISO Recorder Power Toy (isorecorder.alexfeinman.com/isorecorder.htm) is a free ISO burner for WinXP users. At press time, this software didn't work with SP2, although the author expected to have a fixed version available shortly.

To begin the installation, we inserted our KnoppMyth CD-ROM into our DVD drive and booted the system. We pressed ENTER at the boot prompt to load the installer. The main menu isn't much to look at, but it has a handy Auto Install option. We skipped setting the time zone (you can set it again later) and provided the system with a full name, username, password, and an administrative (root) password. We then watched while the system partitioned our hard drive and installed the proper files.

The installer ejected the CD-ROM after finishing the installation. After rebooting, we started the post-install configuration by providing the administrative (root) password when prompted. We then set the proper time zone and opted to delete any previously configured video cards and program guide information (just to make sure we were starting from scratch). Eventually, we were presented with the MythTV backend configuration menu.

The configuration menu was our first glimpse into the MythTV interface. You can use the keyboard or mouse to navigate and adjust values. Unless you're networking multiple MythTV boxes, you can skip the General section.

We started by selecting Capture Cards and selecting New Capture Card. We selected the DVR250/350 option and then selected Finish. To return to the main menu, we pressed ESC.

Before we moved on, we needed to sign up for an account from Zap2it.com. Zap2it provides channel and program listings you can import into MythTV. First, we needed a proper certificate code from Zap2it so we pressed CTRL-ALT-F2 to get to a command line. We typed **tv_grab_na_dd —configure** and were presented a list of time zones. We selected our proper time zone (paying attention to the fact that we were in Daylight Savings Time) and received a certificate code that we wrote down. We couldn't yet proceed with the configure program, so we pressed CRL-C to exit and pressed CTRL-ALT-F7 to return to the setup program.

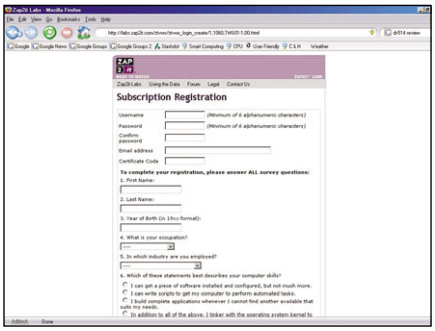
We took the code to an Internet-connected computer and visited labs.zap2it.com. We signed up for a new account and entered the certificate code we received earlier. After answering a few questions, we added the proper lineup and were finished.

Returning to the setup program and selecting Video Sources, we highlighted New Video Source and provided an appropriate name (we used the oh-so-original "Cable" label). We entered the Zap2it.com username and password we created and clicked the Retrieve Channel Lineup button.

After selecting Finished and pressing ESC to return to the main menu, we selected Input Connections, choose the Tuner line, and then selected Cable (or whatever label you used for the video source in the previous menu). After selecting Finished, we pressed ESC to return to the main menu.

You shouldn't have to make any changes in the Channel Lineup menu, so press ESC to exit the back-end setup utility. The install script will download the latest listings and set up your MySQL database. Once complete, it will launch the MythTV front-end.

TV Out. The fun was just beginning. Now we needed to get TV Out up and running. We started by modifying the /etc /modules.conf file to load all the modules we need when we boot. We started by exiting MythTV (press ESC) at the main menu. We clicked the desktop and selected Xterm to open a command line window.

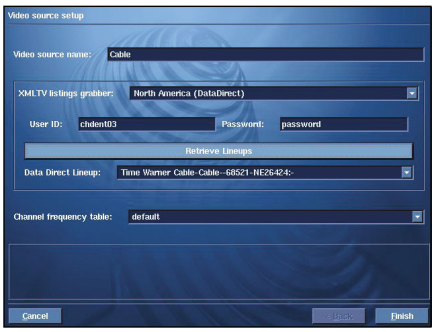


Before you configure your video sources, you need to sign up for an account at labs.zap2it.com. Make sure you get the proper certificate code before signing up online.

We needed root permission to modify the system files, so we typed **su** and entered our root password. We typed **vi /etc /modules.conf** to open the modules.conf file in the vi text editor. Scrolling to the bottom of the file, we pressed *I* to shift from command mode to edit mode in vi and entered the following lines to the bottom of the file:

alias char-major-61 lirc_i2c
alias char-major-81 videodev
alias char-major-81-0 ivtv
options ivtv ivtv_debug=1
options tuner type=2
options saa7127 enable_output=1 output_select=0
options msp3400 once=1 simple=1
add below ivtv msp3400 saa7115 saa7127 tuner
add above ivtv lirc_dev lirc_i2c ivtv-fb

We pressed ESC to return to command mode and typed **:wq** to save the file and exit vi. To update our modules, we typed **depmod –a**. Next we needed a little bit of information, so in the terminal window we typed **tail –f /var/log/messages**. We opened another terminal window and typed **modprobe ivtv-fb**. Returning to the first terminal window, we saw a message reading fb0: iTVC15 TV Out Frame Buffer Device and took note of the fb0 designation.



Once you've signed up for a Zap2it account and configured at least one channel lineup, you can configure the Video Sources. Use the username and password you created when signing up for the account.

From the terminal window, we typed **rmmod saa7127** followed by **saa7127 enable_output=1 output_select=0 testimage=1**. A color test pattern appeared on our television. This meant we had TV Out working. We typed **rmmod saa7127** and then typed **modprobe saa7127 enable_output=1 output_select=0** to reload the module without the test image.

Next, we needed to modify our XF86Config-4 file to support TV Out. We weren't able to get support for TV Out and VGA out at the same time, but we came up with a way to easily switch between the two. In a terminal window, we opened our XF86Config-4 file by typing **vi /etc/X11/XF86Config-4**. Before we made any changes, we typed **:w /etc/X11/XF86Config-4.monitor** to save a copy of the original file. The first section should begin with Section "ServerLayout" and include a line that begins with Screen. Change this line to read:

Screen 0 "TV Screen"

Next we modified the three sections below as follows:

Section "Module"
Load "dbe"
Load "v4l"
Load "extmod"
Load "type1"
Load "freetype"
Load "glx"
EndSection

Section "Monitor"
Identifier "NTSC Monitor"
HorizSync 30-68
VertRefresh 50-120
Mode "720x480"
D: 34.563 MHz, H: 37.244 kHz, V: 73.897 Hz
DotClock 34.564
HTimings 720 752 840 928

```
        VTimings 480 484 488 504
        Flags   "-HSync" "-VSync"
      EndMode
  EndSection

  Section "Device"
      Identifier  "Hauppauge DVR 350
iTVC15 Framebuffer"
      Driver      "fbdev"
      Option      "fbdev" "/dev/fb0"
      BusID "0:0x08:0"
  EndSection
```

If you got a different fb value when you ran modprobe ivtv earlier, replace fb0 with the correct value. To find the BusID, run lspci as root in a separate terminal. Add 0x to the beginning of the BusID.

Finally, we made sure the Section "Screen" portion looked like this:

```
  Section "Screen"
      Identifier  "TV Screen"
      Device      "Hauppauge DVR 350
iTVC15 Framebuffer"
      Monitor     "NTSC Monitor"
      DefaultDepth 24
      DefaultFbbpp 32
      Subsection "Display"
        Depth 24
        FbBpp 32
        Modes "720x480"
      EndSubsection
  EndSection
```

We pressed ESC and typed **:w /etc/X11/XF86Config-4.tvout** to save our changes to a new file and exit vi. We typed **vi /usr/bin/tv** to create a new text file and entered the following lines:

```
#!/bin/bash
cp  /etc/X11/XF86Config-4.tvout
/etc/X11/XF86Config-4
```

To save the file and exit vi, we typed **:wq**. Next, we typed **vi /usr/bin/monitor** and entered the following lines:

```
#!/bin/bash
cp /etc/X11/XF86Config-4.monitor
/etc/X11/XF86Config-4
```

We pressed ESC and typed **:wq** once again. Next, we made both files executable by typing **chmod 776 /usr/bin/monitor** and **chmod 776 /usr/bin/tv**. To change to a TV configuration, we typed **tv** from the command line. After rebooting the system, our MythTV interface was visible on our television set.

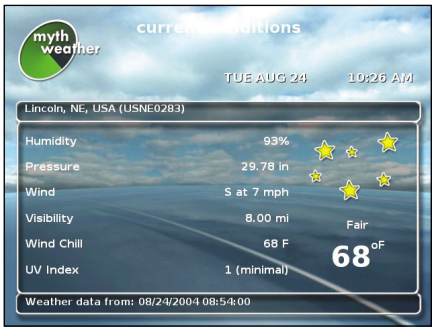
Select a recording to view:
The Clip Show 7/29 5:30 PM
The Van Buren Boys 7/28 8:30 PM
The Money 7/28 8:00 PM
The Bubble Boy 7/28 6:00 PM
The Comeback 7/28 5:30 PM
The Puerto Rican Day 7/27 6:00 PM
The Little Jerry 7/27 5:30 PM
Crossballs
Failure Is Not an Op
Seinfeld
The Daily Show Wit
The Simpsons
16 TBS
Wed Jul 28, 8:00 PM - 8:30 PM
Seinfeld
The Money
Jerry's parents sell their Cadillac, thinking he needs money; J. Peterman returns.

Here's MythTV up and running on our television.

Troubleshooting. Our MythTV box didn't run well at first. Both live and recorded television programs were very choppy. We used a special video driver to fix the problem. This isn't a perfect solution, as it causes some interface glitches, but it's definitely better than watching lots of choppy video.

We downloaded the driver from membres.lycos.fr/badzzzz (click the link to the Binary Version Of X Driver). Once downloaded, we unzipped the file by typing **gunzip ivtvdev_drv.o.gz**. We then copied the file to the correct directory by typing **cp ivtvdrv_drv.o /usr/X11R6/lib/modules/drivers/**.

To use the new driver, we had to change our TV Out settings in our XF86COnfig-4 file. We typed **vi /etc/X11/XF86Config-4.tv** and scrolled down to the Section "Device" portion of the file. We changed the reference to **fbdev** in the Driver line to **ivtvdev** and then pressed ESC and typed **:wq**. We typed **tv** at the command line and rebooted the system. The new driver provided better, smoother output for us.



One of the great things about MythTV is its extensible nature. A Weather module, Music module, and even a Games module adds functionality.

Testing

Overall, we were relatively happy with our new DVR. MythTV's open-source nature makes it easy for interested parties to add new features. This is one of the most exciting aspects of MythTV. Our system included a Newsfeeds feature that let us view the latest headlines from Slashdot, Arstechnica, and other online news sources. Our local weather was just a click away (including a recent Doppler radar image). When we tired of one interface, we could quickly change our MythTV appearance to one of the several included Themes.

MythTV includes a MAME emulator. If you're not familiar with MAME, it lets you play old arcade games on Linux. You'll need to download and install ROM image files to play games. A DVD feature lets you watch DVDs and even rip DVDs to your hard drive. We're not exactly sure how legal these DVD features are, but they appear to need further configuration anyway.

MythTV, however, isn't perfect. As a DVR, there are plenty of things TiVo does better. TiVo, for instance, is excellent at helping you find new programs to watch with features such as Suggestions and Wish Lists. Without these features, it can be difficult to find new shows or even a movie.

MythTV also has a number of small bugs (the program preview screen, for instance, didn't seem to scale properly when we pulled up the channel guide) and the system was pretty unstable. Active development of MythTV will hopefully mean more stability in the near future.

Final Remarks

Due to some of the above problems, we've rated this build as one of the more difficult builds in this issue. A KnoppMyth update could make some of the problems we describe here irrelevant or create new hassles making Linux experience a plus. Regardless, patience and a knack for finding solutions on your own are imperative skills for tackling this build. RS

by Chad Denton

Best Media Center PC Under $1,500

Combine Home Entertainment & Personal Computing

Build #16 Skill Level: 1 2 3 4 5 ***Master***

Without closer inspection, our media center PC fits right in with our home theater.

At last, our prayers have been answered. We've managed to construct a device to check our email, listen to glorious 7.1-channel sound, and record "Magnum PI" reruns. Plus, this handy dandy device innocently masquerades as another piece of electronics equipment.

Goal

Our immediate goal was to build a media center PC for under $1,500. This amount will net you a pretty decent system if you're building from scratch or give you excellent options if you're building around an existing home theater setup. We also wanted our media center PC to look like an ordinary home theater component.

Background

Media center PCs hone in on a simple idea—creating a device that will satisfy power PC users and home entertainment consumers. Imagine renting a movie online and having it streamed to your TV after only a few mouse clicks. Order products seconds after watching a commercial for them. It's not as Orwellian as you'd think. In fact, the above chores are standard for today's systems. Some include remote controls for users to fully enjoy their PC and entertainment system without being chained to their desks.

Microsoft has even designed an OS centered on these systems; it recently introduced the Windows XP Media Center Edition. It's a great OS for these PCs, but Microsoft has only offered this specialized OS to giant PC makers such as Dell and Gateway.

It's disappointing the average PC builder can't acquire WinXP Media Center Edition without buying an entire PC (and thus defeating the purpose of building one in the first place). In all honesty, though, most of the vital components we needed for our system included pretty admirable software that performs about the same tasks as WinXP Media Center Edition. We used an OEM copy of WinXP Home Edition for our OS.

Finding the right case, which can be a mundane chore for some PC builds, was one of the more interesting steps in the process. A quick search for cases specially designed to be media center PCs revealed several manufacturers including Antec, Ahanix, Silverstone, and Kanam (and may suggest media center PCs are no longer a niche market).

Heat and noise were two special concerns for our system. We didn't want a small case turning our enclosure into a hamster sauna or loud fans making the PC a distraction in a home theater setup. We started with an oh-so-sexy Ahanix D. Vine 5 black case and selected an Ahanix 400W SilenX power supply, iMON Universal IR Remote Control, and an Ahanix Vacuum Fluorescent Display as additions. The entire setup cost about $330.

We needed a video card that could give us amazing graphics performance, a TV tuner, and video capture card, and ATI came galloping to the rescue on its faithful steed, the AIW (All-In-Wonder) 9800PRO video card. There aren't too many cards as expensive as the AIW 9800PRO, and it's easy to see why. In addition to a respectable ATI 9800PRO GPU, the card has a TV Tuner; ATI's Remote Wonder; Guide Plus (a handy program that helps you record programs, as well as view TV programming schedules in advance); and TV ON-DEMAND, which can record TV programs and pause live TV. Goody.

With the AIW 9800PRO handling our graphics, we selected a midrange Pentium 4 for our CPU. We used a 2.8GHz

800MHZ FSB P4 with Northwood core; we were wary the notoriously hot-running Prescott would generate unnecessary heat. If you prefer going with AMD, an Athlon XP 3200+ ($182) is about on par with what we paid for the P4 ($180).

We turned to MSI for our mobo, and the company didn't disappoint us. MSI's Neo2-PFISR board supported our CPU's 800MHz FSB and SATA hard drive and had four DIMM slots to accommodate up to 4GB RAM. We didn't need the integrated audio, but this would come in handy if we were building a system that didn't require cutting-edge sound cards.

Loading up on memory wasn't really crucial, but we still wanted enough to handle multiple tasks with ease. We picked up two 512MB PC3200 memory modules of Corsair Value Select RAM.

When we selected a hard drive, we had to have a drive to store episode after episode of "Magnum PI." (Call it moustache envy; we call it one of the greatest shows of the '80s.) Picking a SATA drive was almost imperative; not only would we achieve faster data transfer rates, the SATA cable would take up far less room in our already cramped case. While we used an extra 250GB Western Digital hard drive we already had on hand, we factored the 200GB WD200JD ($129) into our budget. We can only hope we made you proud, Mr. Selleck.

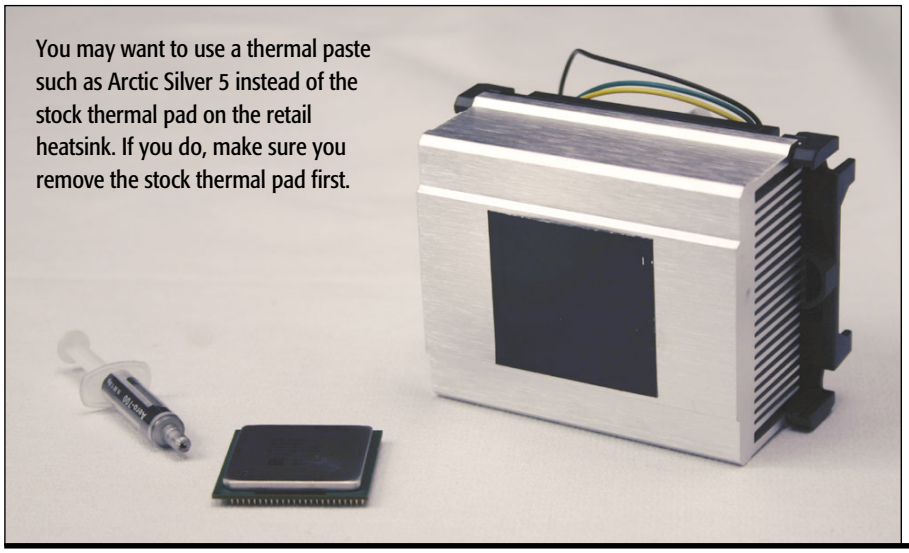
Although we purchased Ahanix's remote control, we also bought a wireless keyboard and mouse combo from Belkin to make sure we covered our bases.

Sony's Double Layer DVD Recorder would have been the perfect solution for our media recording needs, but our belt was getting a little tight after we had purchased our other goodies. Instead, we tracked down a dual-layer black NEC drive that wasn't exactly the crème de la crème, but it will probably still satisfy most users.

Parts List

Component	Model	Price	Notes
Case	AHANIX Dvine 5 Series Case Black	$190	
Power Supply	AHANIX SilenX 300W PSU	$42	Included with case
Motherboard	MSI 865PE Neo 2	$123	
Processor	Intel 2.8GHzC Pentium 4	$178	
Memory	1GB Corsair Value Select RAM	$171	
Hard Drive	Western Digital SATA Hard Drive	$129	OEM
Video Card	ATI All-In-Wonder 128MB Radeon 9600XT	$184	
Sound Card	Creative Labs Audigy 2 ZS	$79	
Network Card	Integrated Into Motherboard	$0	
CD Drive	See DVD±RW Drive	$0	
DVD-ROM/ CD-RW Drive	See DVD±RW Drive	$0	
DVD±RW Drive	NEC Dual Layer DVD±RW Drive	$87	OEM; After $40 mail-in rebate
Monitor	None	$0	
Speakers	None	$0	
Keyboard	Belkin Wireless Keyboard	$32	
Mouse	Included With Keyboard	$0	
Remote Control	iMON	$43	
Case Display	Ahanix D.vine Series Vacuum Fluorescent Display	$49	
OS	Windows XP Home	$64	On sale. Clearing out SP1 before SP2 release.
Total		**$1,371**	

We should also point out that our system doesn't include a monitor or speaker array. We wanted to focus on the system itself and could have written separate articles about picking the right display and sound system. When you factor in these costs, the price will likely exceed $2,000, but consider you're getting a top-notch PC, DVD player, DVR, and stereo receiver in one device—not too shabby.



You may want to use a thermal paste such as Arctic Silver 5 instead of the stock thermal pad on the retail heatsink. If you do, make sure you remove the stock thermal pad first.

The Build

Considering we're used to using traditional cases in our builds, we'll focus on installing our components in the case. After all, the D. Vine 5 is really the star of the show.

All things considered, this is a sharp case. On the outside, the D. Vine 5 arrived at the party dressed to impress. With its jet-black, brushed aluminum finish and only an opening for the optical drive tray, only the power and reset buttons on the front gave us any clue a computer could hide under the hood. Despite its attractive appearance, we discovered some limitations when we cracked the case open.

Surprise! When we opened the Ahanix case, we found that it was already outfitted with a PSU and VFD. We visited Axion Technologies' (where we bought the case) Web site, but it was unclear that these two components should be included. The preinstalled PSU was only 300W, and we wanted the extra juice from our 400W SilenX PSU. If we had paid a little more attention to Ahanix's Web site, we would have seen the D.Vine 5 case is only compatible with MicroATX PSUs; we'd have to stick with the stock PSU.

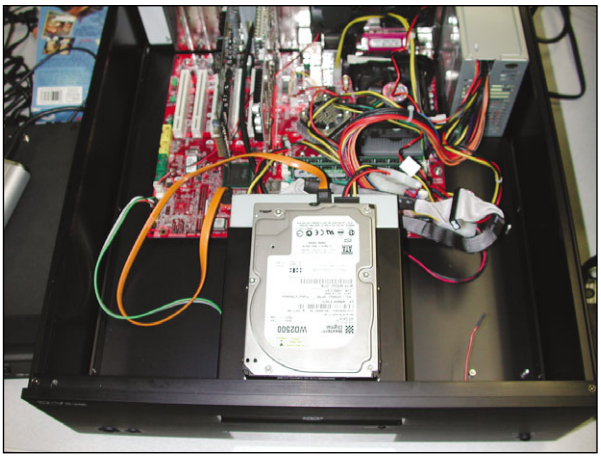
Ahanix opted for two 60mm case fans instead of an 80 or 120mm fan. It certainly looked like these fans would silently cool our media center PC, and we were still a little worried that they wouldn't be able to move enough air. While we weren't too concerned about the Pentium 4, we considered our AIW 9800PRO might be a heat concern. This is definitely not an overclocker's case.

Case logic? Although Ahanix's online users manual indicates the drive cage is removable, the screws were so tight they seemed soldered in place. Unless you're able to remove the drive cage, you must install your optical drive before you install your CPU or graphics card. We also removed our optical drive's tray cover and front cover; the disc tray is the only visible part of the drive, and Ahanix includes a tray cover to match the case. We mounted our hard drive on top of the cage, but it looked like Ahanix has included room below the optical drive for a second hard drive. But, as you'll find out, this is probably a bad idea.

In hindsight, we would have purchased a MicroATX mobo for this build once we installed our ATX mobo. Our optical drive's IDE pins were literally less than an inch from the headers on the board. While were able to tuck the IDE cables out of the way, it wasn't an optimal configuration by any means. In this case our SATA cable was a godsend; we would have had a sticky situation with another IDE cable.

The case's two 60mm fans were an interesting feature, too. One fan used a Molex header, while the other fan connected to our mobo. When we connected this fan to our mobo, the cable would only reach the header after we weaved it underneath our graphics and sound cards. Why Ahanix didn't spend some extra coin to make this cable longer will forever be a mystery. At any rate, it might be worth a few extra dollars to buy another 60mm fan.

Speaking of cables, the VFD connected to our system using our motherboard's parallel port. The cable runs from the VFD out the case and attaches to the parallel port on the back of the computer. This effectively eliminated one of our available PCI slots, which wasn't a big deal in this case because the AIW 9800PRO's heatsink rendered the nearest PCI slot useless anyway.



A crowded middle offsets the wide-open spaces on either side of the D. Vine 5's front.

Setting up the BIOS, SATA, VFD, and AIW. When we powered on our PC for the first time and didn't receive a POST screen, we immediately went to work in the BIOS. From the BIOS main menu, we went to Integrated Peripherals, On IDE Configuration, ATA Configuration, and changed the setting to PATA And SATA. While we were still in the On IDE Configuration menu, we went to Combined Mode Option and set it to 1st Channel PATA. We returned to the main menu and went to Advanced Bios Settings. We set our boot device order to the following: floppy first, CD/DVD-ROM second, hard drive third. We pressed F10 to save our changes and exit the BIOS.

Some of you may be wondering how we configured WinXP Home to recognize our SATA hard drive when the D. Vine 5 case didn't include room for a floppy drive. Because we only needed the floppy drive to install our SATA drivers, we temporarily attached one while our case was still open. We pressed F6 when WinXP prompted us to do so for a third-party SCSI or RAID driver. Otherwise, we didn't encounter any anomalies during our WinXP installation.

After we had installed our mobo's drivers, we turned to the VFD and received mixed results. First, the documentation is sparse. We went to www.ahanix.com/support and clicked Stand-alone VFD Instruction because our VFD connected to our parallel port. (There's also a USB version that uses different drivers and software that is also available at Ahanix's support Web page.) We downloaded the Parallel Port Driver, installed it, and downloaded the Smartie 5.1 software Ahanix recommended. We followed Ahanix's instructions to configure the VFD.

We had mixed feelings about the VFD. For starters, it appears Ahanix doesn't have any proprietary software for the VFD. Smartie 5.1, though it worked properly, didn't have many display options besides PC specs (CPU clock speed, hard drive capacity, etc.). Because we wanted our media center PC to look less like a PC and more like a home theater component, we thought this was a small step in the wrong direction. On the other hand, staring at a blank display could give the impression the display is broken, so the jury's still out on the VFD.

Installing the Sound Blaster Audigy2 ZS before the AIW 9800PRO was helpful. The Sound Blaster Audigy2 ZS's users manual told us to ignore the Add New Hardware Wizard when we installed the card. Instead, we clicked Start and Run and typed **d:/ctrun/start.exe** to start the installation process.

The AIW 9800PRO was also fairly simple. Before we installed the drivers and software, we attached our coax cable to the AIW 9800PRO's TV Tuner. You'll need

System Notes	
Dimensions (inches)	5.9 x 17.1 x 18
Form Factor	ATX or Micro ATX
System Specs	
Motherboard	Supports Intel Pentium 4 processors (Northwood/Prescott cores), Intel 865PE + ICH5R, FSB 800/533/400MHz (Northwood only), four dual-channel DIMM slots, 2X SATA (RAID 0/1), 2X ATA 100 up to four devices, eight USB 2.0 ports, six-channel integrated audio, 10/100/1000Mbps integrated LAN
CPU	Intel 2.8GHz Pentium 4 (Northwood), 800MHz FSB
Memory	1GB (2x 512MB) PC3200
Hard Drive	200GB SATA Hard Drive; 7,200rpm
Video Card	128MB Radeon 9800PRO
Software Highlights	Windows XP Home SP1
Performance	
3DMark03	5726
PCMark04	3882
Outstanding Features	
Weakest Links	Versatile graphics card defines multimedia performance, giant hard drive will store hours of recorded video, quiet and inconspicuous case fits perfectly with any home theater setup.
Summary Remarks	Speakers and monitor not included in price, poorly positioned motherboard standoffs and drive cage makes the case cramped in some areas and barren in others, possible overheating concerns
Degree Of Difficulty	A perfect PC for anyone who wants to combine computing and home entertainment in one room. Except for a few minor clues, no one will know your latest home theater component is a PC in disguise.

to do this when the Initialization Wizard scans your Cable TV channels. Next, we inserted ATI's CD in our drive and clicked Install twice to begin the installation process. We clicked Next a lot and looked over the default destinations for the included software, but we hit a small snag trying to connect the output breakout cable to our sound card. We had to use the Mic In input on our sound card to hear anything. If you skip this step, you won't be able to hear sound when you watch TV.

Because we were a little curious (and very thrifty), we thought we'd see if the ATI remote would serve our needs. With any luck, we could use the ATI remote, ditch the IMON remote, and save about 50 bucks in the process.

Testing

We wanted our media center PC to be an entertainment jack-of-all-trades, so we ran a series of benchmarks to see how our system would stack up as a gaming and a general use PC. We tested the TV Tuner's video capture abilities and also evaluated TV-ON-DEMAND's pausing live TV feature. The TV Tuner test results would be less quantitative than benchmarks such as 3DMark03 or PCMark04, but we wanted to know if our system would measure up as a true media center PC.

When we ran 3DMark03, our rig returned a fairly respectable 5726 score. Our PCMark04 score of 3882 was also acceptable. Our PCMark04 and 3DMark03 benchmarks indicated we had built a solid computer, but testing the TV Tuner and ATI remote control would be the deciding factor on our machine's true value.

We clicked TV from the ATI taskbar (which by default appeared along the right side of our display), and the Initialization Wizard helped us set up the TV Tuner. You'll want to pay special attention to the TV-ON-DEMAND Wizard portion of the Initialization Wizard. We clicked Advance Settings, clicked High CPU Load for Processor Load, and adjusted the Image Quality and Video Performance sliders to High. These settings will result in a shorter amount of time to pause live TV, but with a 200GB hard drive, the difference was like pitching a lawn chair off the Titanic in an effort to keep it afloat.

The TV picture looked average on our monitor at a full screen size, but this is because NTSC, the broadcast format for cable TV, has a maximum resolution of 648 x 486. The TV picture looked fantastic when we connected a 20-inch Apex TV to the AIW 9800PRO using the S-Video cable ATI included with the card.

ATI's TV-ON-DEMAND knocked our socks off. When we clicked TV again, we clicked the pause button on the control panel. When we waited for about two minutes and clicked play to resume watching, we couldn't tell any differences between the resumed broadcast and an ordinary live broadcast. While the audio and video were synced in our test, it's possible that it could deteriorate over time. Still, the results were good enough to convince us we wouldn't be shopping for a TiVo for a long time.

After receiving our impressive results from the TV Tuner and all of its features, testing the remote control was somewhat anticlimactic. Don't get us wrong, ATI's remote did everything we wanted. To emulate a mouse, the remote has a directional pad and two buttons that act as left and right mouse buttons. Changing channels and navigating DVD menus was a snap with the ATI remote. The USB receiver picked up a signal from well over 20 feet away, meaning you'll be able to easily use this media center PC from the comfort of your sofa.

During the testing of our media center PC's performance, we also evaluated a crucial part of this system: noise. The stock fans seemed to cut down the noise to a level that made our PC as quiet as any other piece of home theater equipment. Well done, Ahanix.

Final Remarks

While we didn't factor in the cost of a grandiose flat-panel TV or wall-rattling speakers, our media center PC is still an incredibly versatile, entertaining machine, and it cost less than $1,500 to boot. While you're still drooling, let's remind you that adding Internet access turns the rig into a true multimedia powerhouse. You may never leave the living room again. RS

by Vince Cogley

CREATE A DUAL-XEON PC

Our Dual-Processor System Struggles To Life Despite Our Best Efforts

Build #17 Skill Level: 1 2 **3** 4 5 ***Journeyman***

As PC junkies, we love computer power in any form. We always want to add more storage, speed up the system's components, and add new peripherals. We often upgrade by buying more of the items we already have. Is your 80GB hard drive almost full? Buy another hard drive. Don't have enough memory? Buy more. In general, we expect large performance increases whenever we double a component. However, we don't expect a huge performance increase for every application when we add a second processor. Unlike hard drives, with which double the drives means double the storage, the second CPU doesn't double the system's performance. Think of the processors as a tag team; while one processor handles one application, your other processor focuses on a different task.

That's not to say that the second processor doesn't add performance; it makes a huge difference to users who regularly handle resource-hogging programs, such as CAD and DV programs. As a result, you'll find dual-processor systems in many workstations. Don't build a dual-processor system if you simply want to play the latest games; you'll enjoy your system much more if you put that money toward the best video card you can afford. But if you edit home videos and you're sick of your slow, old PC, or if you want to build a dual-processor server, read on.

Goal

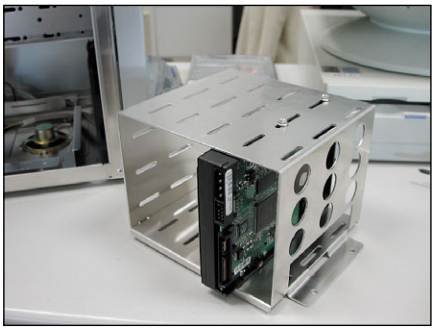
We had a $1,500 budget, more or less, which meant that we couldn't grab Intel's hottest Xeons for our rig, but we weren't worried. Our focus was dual-procs (and consequently, the mobo), so we planned to skimp a little when we bought other components such as the case, hard drive, and optical and floppy drives. We crossed the monitor off our list right away; we have plenty lying around. Speakers? Forget it. This a dual-proc system, not an entertainment PC.

Our plan was to build the best Intel-based dual-proc system we could (within budget) and then compare it to the best AMD-based dual-proc system we could wrangle under the same budget constraints (see page 76). Sure, we're not comparing apples to apples, but then, we're not trying to build identical systems. Instead, we want to find out which processor-mobo combo offers more power for the price. And so begins the battle of the Xeons and the Opterons.

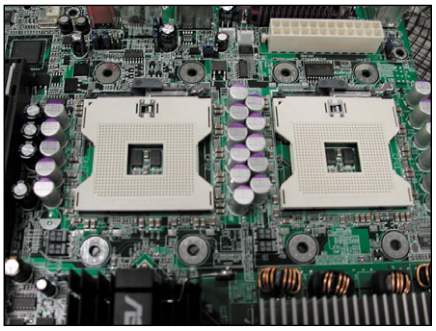
Background

We focused on the basic items before we turned our attention to the system's motherboard and processors. Keyboard? Check. If we were shopping for a solid but cheap keyboard and mouse, we would have gone with the $11 Logitech Desktop Deluxe bundle, but we decided to swipe whatever we could from *CPU* staffers. We grabbed a standard IBM keyboard and mouse and then headed to a nearby ownerless system (we hoped) and yanked out the CD-ROM and floppy drive. Our system spec chart lists products we would have bought if we weren't busy ripping off our neighbors.

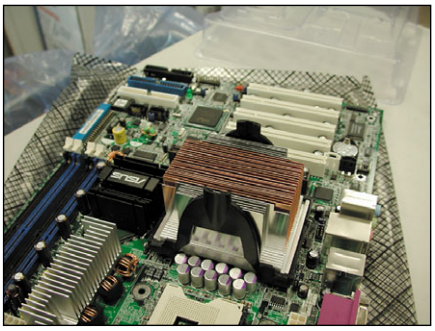
We moved on to items that we didn't already have, such as the chassis. We wanted plenty of elbow room, but we didn't want to commit to a full tower. After scouring the net, we found the modestly sized Lian-Li PC-65. Lian-Li has a reputation for creating quality cases, so we weren't surprised to see that the case, which didn't even include a PSU (as cases often do) cost a whopping $109. We debated briefly and decided that we'd rather take the quality



You can easily add or remove up to five hard drives from the chassis' removable hard drive cage. A fan blows cool air through the cage to keep your drives from overheating.



Sure, capacitors crowd the CPU sockets, but Intel's ultra-thin heatsinks don't touch any of the nearby components.



The aluminum and copper heatsink fits snugly between the retention frame's bridges. The bridges later lock the heatsink cover into place.

case than risk cutting our hands on the sharp edges of a cheapo case.

Finding a solid PSU wasn't difficult. We snagged the Enermax Noisetaker that graced a couple of our other systems. The PSU boasts 470W and is extremely quiet; if you're looking for a powerful PSU that won't generate much noise, you've just found it. Thanks to a $15 rebate, the PSU cost only $69. Unfortunately, our rebate kismet didn't last—we couldn't find an 80GB SATA hard drive that included a rebate. We settled on a $73 Maxtor drive that served us well. We briefly considered buying a second hard drive but scrapped the idea; we didn't want to pull money out of the motherboard/processor pool.

That said, we couldn't bear the thought of a system that didn't have a halfway-decent video card, so we scouted for a sub-$150 graphics card and came up with the PNY NVIDIA GeForce FX5700LE, which has 128MB of DDR memory. Because it cost just $132, the card didn't really hurt our wallet, so quit frowning.

Next, we looked for a dual-socket motherboard that would support Xeon processors. We liked the ASUS PC-DL Deluxe, which cost a whopping $201 but boasts support for ATA133 RAID and SATA RAID configurations. The board also has Gigabit Ethernet support and dual-channel memory slots. The PC-DL Deluxe includes Intel's 82875P northbridge and 82801 southbridge. Unlike the AMD system's MSI K8T Master2-FAR, which requires registered ECC memory, the ASUS board supports unbuffered PC2700 DDR SDRAM. We promptly tracked down 1GB (two 512MB DIMMS) of non-ECC, unbuffered Kingston ValueRam. At $177, the memory isn't cheap, but the Kingston memory carried a lower price tag than most, so we weren't complaining.

We were pleased to see that we still had plenty of cash for our processors. We chose the Xeon 2.4AGHz, which boasts a 1MB L3 cache. We could have bought a Xeon that had a faster clock speed, but we liked the large L3 cache and we liked the price: $279 each, for a total of $558. We double-checked to make sure that the processors' FSB matched the board's 533MHz FSB and then placed our order.

The Build

We opened our chassis without any trouble, thanks to its thumbscrews. Thumbscrews secure most of the removable chassis components, so if you have a tendency to lose your screwdriver, you'll love this case. We started by screwing the case's PSU backplate onto our Enermax PSU and then slid it into the case, careful to keep the cables near the top of the case so that they didn't clog our system while we worked.

Installing the drives. The Lian-Li PC-65 has a stationary drive cage and doesn't include or accept drive runners, which meant that we had to remove both of the case's side panels to install our ASUS CDS520. We grabbed the bottom of the chassis' front panel and then pulled towards us, popping the panel off the case without much effort. Unlike many cases, the PC-65's front panel doesn't have any data cables or PCBs attached to it, which means you can easily pop it off to access the front of your case. The front of the case does have several ports, including two USB ports, but Lian-Li didn't attach it to the removable panel. We're lazy, er, big fans of convenience, so we like this kind of feature.

Thus, we also like the removable floppy drive sled, which houses up to two 3.5-inch drives. As with the optical drive cage, the sled doesn't have runners (after using the Thermaltake Xaser III's screwless drive runners, we cringe whenever we see screws), but we'd rather have the sled than another permanent cage. We matched the front of the drive to one of the sled's bay covers, which meant that when we replaced the front panel, the drive fit perfectly.

Installing the CPU. As you might have guessed, the CPU installation was the most complicated part of the build process. We installed not one but two Intel Xeon 2.4GHz processors, despite Intel's awful instruction poster. When we pulled the poster from the first CPU's package, we quickly determined that the mostly textless instructions' vague diagrams weren't what we were looking for, so we turned to the PC-DL's manual.

As it turned out, ASUS added excellent Xeon installation instructions to its motherboard manual. The guide, which included plenty of text and clear photos, walked us through the process step-by-step. We started by removing one of the processors from its package, lifting the CPU socket's lever, and then dropping the processor

into the socket. We lowered the lever until it locked back into place and then grabbed the backplate and attached it to the mobo so that the standoffs extended to the other side of the board.

Next, we grabbed the CPU socket retention frame. Unlike AMD Athlon 64 retention frames, Intel's Xeon frames have tall plastic bridges. We screwed the frame into place and removed the heatsink from its package. The heatsink already sported a thermal pad, so we didn't need to apply any thermal paste; if you buy a heatsink separately, you'll probably need to use thermal paste. (Some thermal paste manufacturers, such as Arctic Silver, offer detailed instructions on their Web sites.) We pushed the two retention frame bridges gently from the inside so we could slide the aluminum heatsink into the retention frame. We were careful not to catch the thermal paste on the bridges as we installed the heatsink.

We grabbed one of the two metal retention clips that secure the heatsink to the CPU and attached it to the retention frame. The clip has three holes that hook onto the retention frame's tabs. We started by hooking the clip over the middle tab. The middle tab has a special hole that lets you slide the clip just a couple millimeters to the side. We determined that the clip could shift to our left, so we pressed the right clip onto its tab and then shifted the clip to the left so that we could press the final clip over its tab. Unfortunately, Intel didn't add any hooks that would let us use a screwdriver to push the clips down, which meant that we had to rely on thumb power. Ouch.

Once we installed that clip, we performed the same task on the other side of the heatsink. Next, we pulled the large plastic heatsink cover from the CPU's package. The cover acts as a tunnel that guides air across the heatsink's tall fins. You can attach the included fan to either the top of the cover or one the sides. Capacitors and the northbridge's heatsink crowded our motherboard's CPU sockets, which meant that we couldn't install the fan on the side of the cover. Instead, we popped the removable plastic circle from the top of the cover. Thanks to our new hole, the fan could suck air out of the top of this plastic tunnel and throw it away from the CPU. We pushed the fan onto the cover's pegs until the nearby hooks snapped over the bottom edge of the fan.

We finished the cover's installation by sliding it over the heatsink and pressing down until the retention frame's bridges snapped over the cover's side hooks. Finally, we plugged the fan's power cable into one of the two CPU fan connectors. Whew.

System Notes

Intel Dual-Proc System	
Dimensions (inches; Tower Only)	17.7 x 8.3 x 19.3
Weight (pounds; Tower Only)	27.98

Benchmarks

We ran PCMark04 (version 1.2.0, with Windows Media Player 9) and 3DMark03 (build 340, with DirectX 9.0) at default settings. We used Nvidia's Unified video card driver, version 61.77

PCMark04 System	3602
CPU	3713
Memory	3756
Graphics	2053
Hard Drive	4636
3DMark03	2269

Parts List

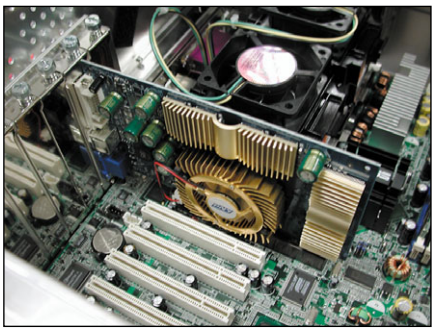
Component	Model	Price
Case	Lian-Li PC-65	$109
Motherboard	ASUS PC-DL Deluxe	$201
Processor	Intel Xeon 2.4A (x2)	$558
Memory	Kingston PC2700 (512MB x2)	$177
Hard Drive	80GB Maxtor 6Y080M0	$73
Video Card	PNY NVIDIA GeForce FX5700LE	$133
Optical Drive	ASUS CDS520*	$21
Floppy Drive	Generic*	$8
Soundcard	Integrated With Mobo	$0
Mouse & Keyboard	Logitech Desktop Deluxe Bundle*	$11
Operating System	Windows XP Pro (OEM)	$141
PSU	550W Fortran FSP550-60PLN RET	$91
Total		**$1,523**

* Equipment previously purchased

We followed the same steps to install the second processor, but we made a crucial mistake when we dropped the CPU into the socket. We didn't notice that the CPU wasn't completely seated on the socket: One side of the processor stood just a little higher than the other. Of course, we noticed this later.

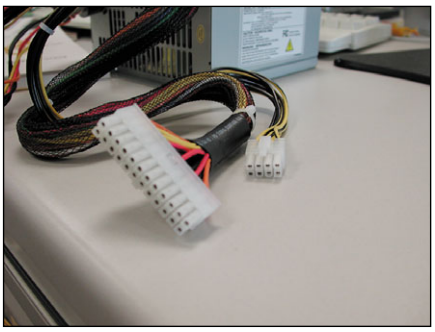
Installing the motherboard. We removed the motherboard tray from the chassis and then replaced the PC-65's I/O port shield with the PC-DL Deluxe's port shield. Next, we screwed several standoffs into the tray and then placed the motherboard on the standoffs so that they matched the mobo's holes. Once we screwed the mobo to the standoffs, we installed the memory. We placed a DIMM into one of the mobo's slots (we used the slot closest to the processors) and pressed one end and then the other until the socket clips snapped into place. The board uses dual-channel technology, so instead of placing the other DIMM in the next slot, we moved to the second set of memory slots. As with the first DIMM, we installed the second DIMM into the leftmost slot. We weren't worried about inserting the DIMMS the wrong way; each socket has a tab near the center that corresponds to the DIMM's notch. Because the tab isn't quite in the center of the socket, you can install the DIMM in only one direction. Next, we pushed the video card into the AGP slot and then pushed the motherboard tray back into the computer.

Once we replaced the motherboard tray, we tried to plug the PSU's 20-pin power connector into the motherboard and immediately discovered that the PC-DL Deluxe has a 24-pin power connector. It also has an 8-pin 12V connector instead of the standard 4-pin connector. Our standard power supply didn't have the appropriate connectors, so we replaced it with a Xeon-friendly 550W Fortran PSU, which meets Intel's SSI (Server



Sure, our PNY GeForce FX 5700LE isn't going to bring 3DMark03 to its knees (in fact, it's the other way around), but then, we're focusing on the processors.

Our first PSU didn't have the appropriate connectors, so we turned to one of Fortran's 550W SSI PSU's, which handled our motherboard's large power connectors just fine.



This Fortran SSI PSU's mobo connectors are larger than standard ATX connectors. The larger one has 24 pins (instead of 20) and the smaller connector has 8 pins (instead of 4).

System Infrastructure) specification. This power supply includes the 24-pin and 8-pin connectors, as well as the standard ATX connectors that power the system drives, which we promptly connected to our CD-ROM, floppy drive, and fans. The PSU has only one SATA power connector, but our system had only one SATA hard drive, so we're not complaining.

We double-checked our CPU power cable connections and attached a monitor, keyboard, and mouse to our system. We pressed the power button and watched the processor fans spin for a few seconds and then stop. That wasn't a good sign. We checked the components to make sure they were attached properly but couldn't find anything out of place. Reluctantly, we disassembled one of the complicated CPU heatsink setups. We couldn't find any physical damage to the CPU, so we replaced the heatsink and then removed the next CPU's heatsink, at which point we discovered that the CPU didn't sit evenly in the socket. We raised the socket lever, eased the CPU into the socket, lowered the socket lever, and then replaced the heatsink. When we pressed the Power button again, the system fired up without any trouble.

Next, we entered the system's BIOS and selected the Advanced tab, which displayed several categories, including Integrated Peripherals. This category breaks into three subcategories, including OnChip Device, which we selected. We scrolled to the SATA settings at the bottom of the page. SATA Mode was gray, which meant that we couldn't adjust that field (yet), so we highlighted the next field, which was On-Chip Serial ATA. We pressed ENTER and selected the SATA Only mode. When we pressed ENTER again, the SATA Mode field became bright, which meant that we could change it. We switched the field from IDE to SATA and then hit F10 to save our changes and reboot the system.

Before we installed Windows we took the motherboard's driver CD and a floppy disk to a functional computer and navigated to the Promise 378RAID folder. We ran MakeDisk.exe, which extracted the drivers to the floppy disk. We returned to our system and began the WinXP Pro installation. We pressed F6 as soon as the Windows installation began. (You'll see a message that directs you to press F6 if you want to install a SCSI or RAID device). Windows loaded several files and then displayed a message that stated Windows couldn't find our hard drive. We pressed *S*, entered our driver floppy, pressed ENTER, and then selected the WinXP version of the driver when the list appeared. Windows continued the installation without a hitch.

Once our system completed the Windows installation, we inserted the ASUS driver CD and installed the mobo's drivers, including the Gigabit LAN driver and audio drivers. (After all, we didn't buy an add-on sound card.) We also downloaded and installed NVIDIA's Unified driver, version 61.77.

Testing

Before we ran the benchmarks, we right-clicked My Computer, clicked the Hardware Tab, opened the Device Manager, and scrolled down to the Processors category. When we clicked the plus sign (+) next to Processors, the Device Manager displayed both of our processors. Now that we knew Windows recognized our processors, we were ready to test our system's performance. We ran two benchmarks: PCMark04 and 3DMark03. 3DMark03 focuses on the video card, so we weren't surprised to see that our system, which sports an older card, scored a measly 2269 3DMarks. However, the system fared better in PCMark04, producing a score of 3602. The system didn't break even with our AMD system, but we're not disappointed in its modest scores.

Final Remarks

Although we met with one disaster after another, we enjoyed piecing together Intel's complicated heatsink equipment. (Which is a good thing, as we assembled each heat-sink setup twice.) AMD builders can get away with a standard ATX PSU when building Opteron systems, but builders planning to assemble a Xeon system should sure to buy an SSI PSU. Our Intel system couldn't top its AMD counterpart, but it may have made a better competitor if we had installed both CPUs correctly the first time around. RS

by Joshua Gulick

CREATE A DUAL-OPTERON SYSTEM

We Double Our AMD Fun With Two CPUs

Build #18 Skill Level: 1 2 **3** 4 5 ***Journeyman***

After we built the Intel-based dual-processors system (see "Create a Dual-Xeon PC" on page 72), we took a stab at a similar AMD-based system. We couldn't use the same motherboard, of course, and thanks to the AMD-based board's special requirements, we couldn't use the same memory, either. However, we used the same amount of memory with the same speed for both systems (1GB, PC2700). We also reused several components, including the chassis, floppy drive, CD-ROM, and video card. Although we can't really make apples-to-apples comparisons of our AMD-based and Intel-based PC's, the two articles will give you a good idea of how much dual-processor system you can buy for $1,500.

Goal

More often than not, you'll find a dual-processor setup in a high-powered workstation. If you want to build one of these, take a look at "Best Heavy-Duty Graphics/CAD Workstation" on page 48. That said, even mild-mannered computers can benefit from the dual-processor package. Our editors asked us to limit our budget to a mere $1,500, not including most peripherals, such as speakers and a monitor. Although we always prefer spare-no-expense challenges (at least, we think we would), we're up to limited-budget challenges, as well. We planned to build a decent PC that would have a reasonable amount of hard drive space and memory, a solid video card, and the best two AMD processors we could afford.

Background

We started our shopping spree by hunting down a reasonably priced motherboard that supported dual AMD Opteron CPUs. Many custom system builders are switching from AMD's former workstation mainstay, the Athlon MP, because the newer Opterons offer more power. As with the Athlon 64, Opterons offer 64-bit processing but are compatible with 32-bit applications. The Opteron also supports more than 4GB of memory, which is the limit for 32-bit AMD-based systems.

We quickly discovered that most AMD-based dual-socket mobos aren't cheap: Almost all of the popular Tyan boards carried price tags above $400, and some cost more than $500. We didn't want to spend a third of our budget on the motherboard alone (after all, we want the processors to take the spotlight), so we dug around for the MSI K8T Master2-FAR, which has moonlighted as an Athlon 64 FX-compatible board. We had a hard time finding a retailer that had the board in stock, but when we finally located the mobo we were glad to learn that it was still priced at a still-expensive $220.

The K8T Master2-FAR sports VIA's K8T800 northbridge and VT8237 southbridge and boasts integrated audio and Gigabit Ethernet (thanks to a Broadcom BCM5705 controller). The board supports AGP Pro 8X and up to 8GB of memory. Oddly enough, the mobo includes its own heatsink/fan combos. We soon found out why: The motherboard's sockets don't support any other

heatsinks, including the heatsinks that accompany the retail version of the Opterons. In retrospect, we should have bought OEM versions of our processors, which would have saved us about $40. You might be able to install your own heatsink if you have the appropriate retention frame, but the motherboard doesn't supply them, and neither do most heatsink packages.

That said, we liked the motherboard's other extras, which included rounded floppy and optical drive cables, two SATA data cables, a SATA PSU power adapter, and a D-bracket that boasts additional USB and audio ports. Our 470W Enermax NoiseTaker PSU had its own SATA power connectors, but we were glad to see the adapters anyway; users who have older PSUs will need the connectors to attach SATA drives.

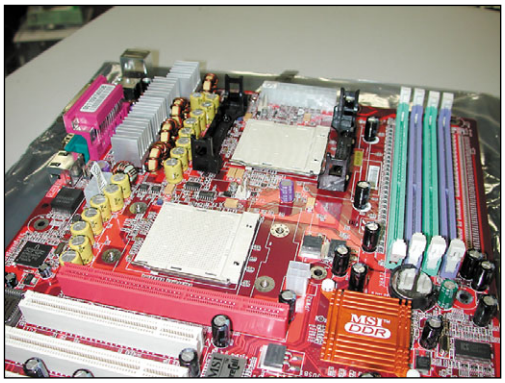
Once we found the motherboard, we hunted down a pair of processors. We settled on the Opteron 242 model, which has a 1.6GHz clock speed and a 1024KB L2 cache. At $220 each, the processors ate up almost a third of our budget. We're sure that they couldn't hold a candle to the 2.2GHz Opteron 248, but the $710 processors would have left us only $80 with which to build the rest of the system.

Next, we bought two 512MB registered ECC DDR DIMMs. Gigaram offered the cheapest DIMMs, which together set us back $258. The motherboard has a slew of processor-based memory requirements, so check them out before you invest in new memory. (You can find the requirements in the description of the K8T Master2 FAR at MSI's Web site, www.msicomputer.com.)

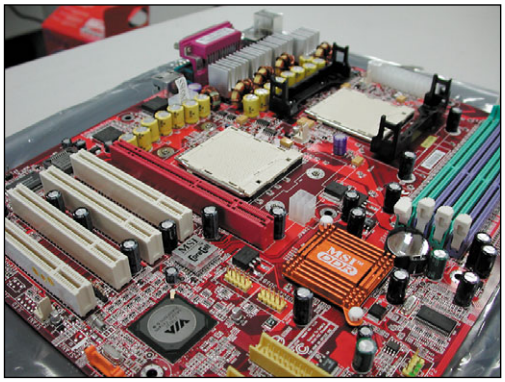
We bought the OEM version of Windows XP Professional for a mere $141. There's no difference between retail and OEM versions of Windows, but you'll need to buy hardware when you buy the OEM version from your local or online computer retailer.

The motherboard and processors drained most of our cash, which meant we didn't have enough money to buy a high-end video card. That said, we easily afforded a PNY GeForce FX5700LE, which supports DirectX 9 and boasts 128MB of memory. It won't lift our system to digital-video-editing greatness, but it'll get the job done. Next, we grabbed a CD-ROM and floppy drive from one of our other computers. We also stripped the computer of its keyboard and mouse; if we were looking for a cheap keyboard and mouse combo, we'd probably go with the Logitech Desktop Deluxe Bundle, which commands a budget-crushing price of $11.

Once we rounded up our keyboard and mouse, we looked for a hard drive.



MSI's K8T Master2-FAR can support a single Athlon 64 FX or Opteron CPU, but why buy one processor when you can have two?



Notice that retention frames stand near one socket but not the other. The socket closest to the AGP slot requires a special heatsink to avoid bumping the video card.

The MSI K8T Master2 FAR has SATA connectors, so we bought an 80GB Maxtor hard drive. We spent the rest of our money on the roomy Lian-Li PC-65, a classy case that let us easily add and remove components. We considered the cheaper PC3077A ($85 to the PC-65's $109), but we noticed that the case would force us to put the PSU in front of the motherboard instead of putting the PSU above the board. Although our system may have fit just fine, we wanted more elbow room than the case offered.

Parts List

AMD Dual-Processor System

Component	Model	Price
Case	Lian-Li PC-65	$109
Motherboard	MSI K8T Master2-FAR	$220
Processor	AMD Opteron 242 (x2)	$446
Memory	Gigaram PC2700 ECC Registered (512MBx2)	$258
Hard Drive	80GB Maxtor 6Y080M0	$73
Video Card	PNY NVIDIA GeForce FX5700LE	$133
Optical Drive	ASUS CDS520	$21
Floppy Drive	Generic*	$8
Soundcard	Integrated With Mobo	
Mouse & Keyboard	Logitech Desktop Deluxe Bundle*	$11
Operating System	Windows XP Professional (OEM)	$141
PSU	470W Enermax Noisetaker**	$69
Total		**$1,489**

* Equipment previously purchased.
** After $15 mail-in rebate.

The Build

Before we started throwing components into our chassis, we opened up all of the packages in our substantial stack and checked to make sure none of the items had any obvious defects. We also grabbed the manuals; once you come across the first mind-boggling problem,

you'll be glad you don't have to dig around for the appropriate users guide.

Installing the drives. We installed the floppy drive without any trouble thanks to the removable drive sled. We unscrewed the sled's thumbscrews, yanked out the sled, and then screwed in the floppy drive. We easily installed our state-of-the-art CD-ROM, but we had to take the other side panel off to secure the drive in the stationary drive cage. That's a minor gripe, we know, but we expected to see drive runners in our expensive chassis.

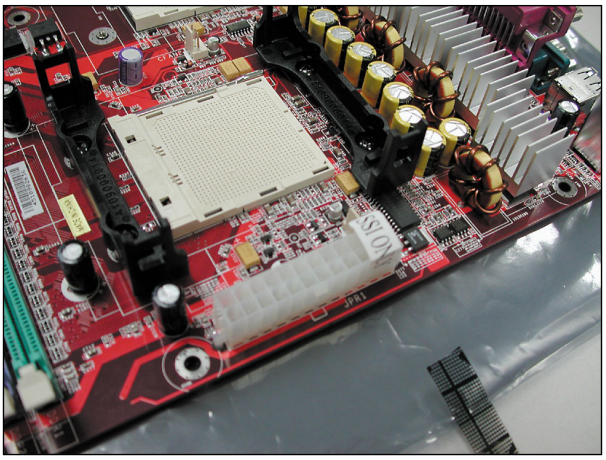
That said, Lian-Li didn't let us down when it designed the removable hard drive cage. Two thumbscrews offer easy access to the removable cage, which supports up to five hard drives. We had only our 80GB Maxtor, which enjoyed the unobstructed airflow of the fan that sits just behind the cage.

Installing the CPU. The MSI K8T Master2 FAR isn't any bigger than other full ATX boards, but it has an extra-large box, thanks to its extra cargo: two heatsinks. The all-copper heatsinks are quiet and cool the CPU without trouble (under normal conditions).

We pulled the motherboard out of the box and then put it on a desk (we kept the foam padding underneath it). Thanks to the new heatsinks, AMD's instructions were worthless, so we relied instead on the mobo manual's vague instructions. The manual calls the CPU sockets CPU1 and CPU2, but the mobo doesn't have any labels that indicate which is which. We found a diagram near the front of the manual that mapped out the sockets: CPU2 stands near the AGP slot, while CPU1 stands closer to the memory slots. If you plan to use only one processor, you'll need to put it in the CPU1 socket.

Although the CPU1 socket appeared to require less assembly (retention brackets stood on either side of the socket), we decided to start with CPU2. We lifted the socket's lever, matched the small triangle on one corner of the processor to the triangle on the corner of the socket, and then dropped the processor into place. We've seen a couple of processors that lack the triangle; if you run into this problem, you can match the processor to the socket by turning it over and looking at the pins near the corners: the pins at one corner form a V instead of a flat edge. Simply match the V to the socket holes' corresponding pattern.

System Notes	
AMD Dual-Processor System	
Dimensions (Tower Only)	450 x 210 x 490mm
Weight (lbs; Tower Only)	27.44
Benchmarks	
We ran PCMark04 (version 1.2.0, with Windows Media Player 9) and 3DMark03 (build 340, with DirectX 9.0b) at default settings. We used NVIDIA's Unified video card driver, version 61.77	
PCMark04 System	4500
CPU	4405
Memory	3884
Graphics	2176
Hard Drive	4563
3DMark03	2396

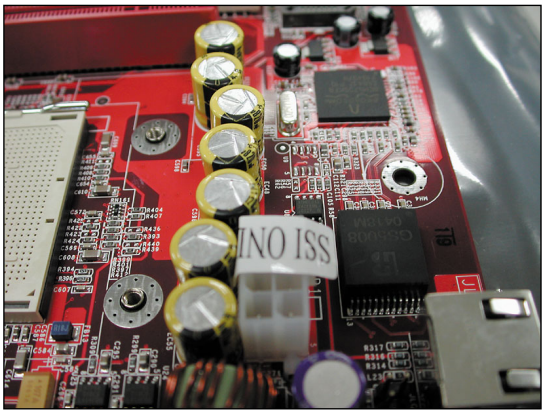


MSI's dual-socket motherboard accepts both the 24-pin SSI power connectors and the popular 20-pin ATX power connectors. The sticker helps users find the appropriate sockets for the 20-pin connector.

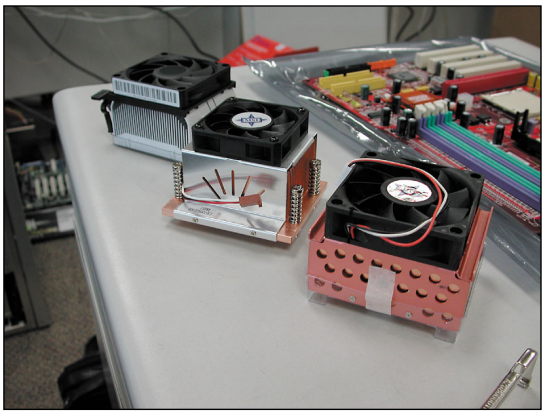
We were surprised to find that the heatsinks aren't identical. CPU2's heatsink doesn't require any kind of retention frame, although it does require a backplate. We found that the backplates for both CPU sockets were already attached to the motherboard, so we pulled the plastic shield off the bottom of CPU2's heatsink (the shield protected the thermal paste), and then placed the heatsink onto the CPU so that the flat end of the heatsink stood nearest the AGP slot. Thanks to the heatsink's slightly off-center design, it won't contact the nearby video card, even if the back of the card has its own heatsinks. Next, we screwed the board's four screws into the backplate's standoffs. We didn't want to apply too much pressure to any side of the CPU, so we twisted each screw a little and moved clockwise to the next screw until we felt that the screws secured the heatsink to the backplate (the manual didn't offer any pointers here). Each screw has a spring that compresses as you twist the screw into the backplate.

Next, we dropped our other Opteron 242 into the remaining CPU socket, CPU1. Unlike the CPU2 heatsink, which had the lip that prevented it from interfering with our video card, this heatsink resembles standard heatsinks. That said, don't plan to swap your own heatsink onto this processor; the retention frame pieces don't have the standard hooks that most heatsinks use. Instead, we hooked one of the metal retention clips into one side of the retention frame, lowered it over the top of the heatsink (which has a groove), and then pressed the thumb tab until the clip locked into place. We then applied the clip to the other retention frame.

If you follow the mobo manual's instructions, you'll notice that they ask you to plug CPU1's fan power connector into the header that stands between the two CPUs. The manual suggests that you plug the CPU1 connector to the mobo before you install the heatsink because the heatsinks stand so close together. We found that you can easily plug the power cable into the connector, even after you've installed the heatsinks, by guiding the cable with a flat-head screwdriver. However, we didn't plug the CPU1 fan's cable into that particular header because we spotted another CPU header near CPU1; CPU2's fan cable can reach only the header that stands between the processors. We also noticed



As with the larger power connector, the small 12V connector accepts up to 8 pins, four more than standard connectors accept.



We've never seen a motherboard that includes its own CPU heatsinks. The K8T Master2-FAR boasts two copper heatsinks, which outshine the aluminum heatsink (at the back of this lineup) that accompanies the retail Opteron.

that the manual's instructions for installing the CPU1 heatsink show someone installing the CPU1 heatsink on the CPU2 socket, which means the manual has pictures of both heatsinks being installed on the CPU2 socket and no pictures of heatsinks on the CPU1 socket. You've gotta love mobo manuals.

Installing the motherboard. Our chassis has a motherboard tray, so we pulled it out and popped the standoffs into the tray. Unlike common standoffs that screw into the mobo tray or panel, these standoffs have two legs. We pushed them through the mobo tray's square holes until they snapped into place and then hefted our now heavy motherboard. We screwed the mobo to the standoffs and then installed our Gigaram memory. We installed our two DIMMs into sockets 1 and 2 (you can also install DIMMs in 3 and 4 or in all four slots at once). If you install an Athlon 64 FX series processor, the slots accept memory at speeds up to DDR400, but if you install Opteron processors, you'll need to use DDR333 (even if you use only one Opteron CPU).

Next, we popped our GeForce 5700LE Optima into the board's AGP slot. As the manual suggested, the CPU2 heatsink's design left plenty of breathing room between itself and the video card. We slid the mobo tray back into the chassis and then used the thumbscrews to secure it.

When we pulled out our PSU's 20-pin connector, we noticed that the board's PSU connector has 24 pins and the 12V connector has 8 pins instead of 4. These large connectors, known as SSI (Server System Infrastructure; an Intel PSU specification) connectors, sometimes accept smaller PSU connectors. The K8T Master2-FAR is one of those ambidextrous motherboards: you can use an SSI power supply or you can toss a standard ATX 12V PSU into your chassis. Of course, you'll need to make sure you put the smaller PSU connectors into the appropriate parts of the mobo connectors. To that end, MSI placed SSI ONLY stickers over 4 pins of each connector. Simply plug your PSU connectors into the remaining holes. If you have an SSI power supply, pull the stickers off.

We wrapped up the build by connecting all of the data and power cables. We were careful not to forget the front panel fan connectors; Lian-Li tucks them between the side panel and the optical drive cage. Next, we replaced the side panel and connected our monitor, keyboard, and mouse to the system. We powered on the PC and then pressed DELETE to enter the BIOS. We checked for settings that might enable the SATA controllers, but we didn't see anything.

Before we installed WinXP Pro, we created a SATA RAID driver floppy. If you have a SATA drive, you'll need to install this driver during the Windows installation. Our trusty mobo manual instructed us to use the driver disk, but the Master2 FAR's package didn't include any floppy disks. To create the disk, we popped the mobo driver CD into a functional computer, navigated to the CD-ROM, right-clicked, and then selected Explore from the context menu. Next, we opened IDE\VIA\SerialATA\1.0D\DriverDisk\SATA. We copied all of the folders and files in the SATA folder, including TXTSETUP.OEM and VT8237, and then pasted them onto our floppy.

Next, we put the WinXP Pro installation CD into our system and then pressed F6 shortly after the installation started. We selected the WinXP version of the VT8237 driver, pressed ENTER, and completed the installation. We loaded the mobo CD's drivers and NVIDIA's Unified driver, version 61.77.

Testing

Our standard benchmarks aren't designed to test dual-processor systems, so we didn't expect outrageous scores, but we weren't disappointed with our system's performance. Our AMD system scored a reasonable 4500 in PCMark04. The hard drive earned the highest category score at 4563, but the CPU score followed close behind at 4405. The PC had a miserable time with 3DMark03, scoring 2269. Even so, it bested the Intel system's score by more than 100 points.

Final Remarks

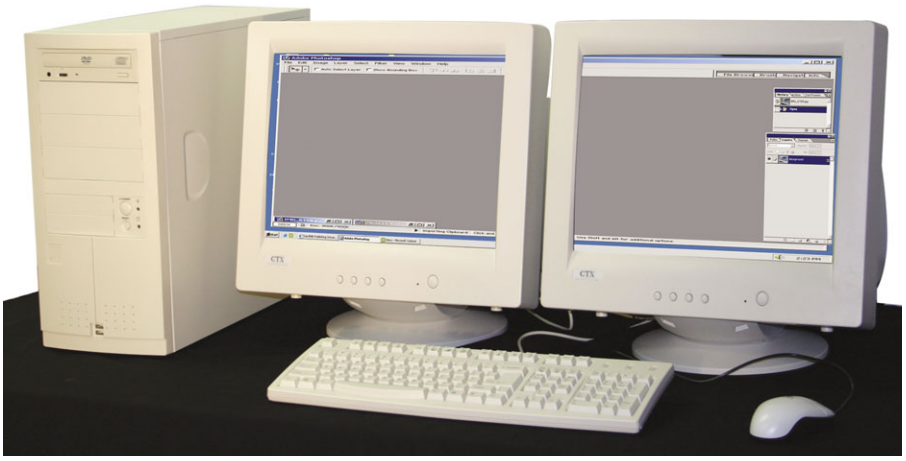
We like the K8T Master2-FAR's specialized heatsinks (we'll take copper over aluminum any day), but we weren't thrilled with the manual. That said, we were able to get our dual-processor system up and running without any serious problems, and our Opteron 242s played nice with WinXP Pro and held their own in our benchmarks, so we're not complaining. RS

by Joshua Gulick

How To Build A Dual-Monitor System

Double Vision

Build #19 Skill Level: 1 **2** 3 4 5 ***Apprentice***



You are probably as familiar as we are with the acts of toggling between applications and dragging and dropping windows and toolbars. As computers gained the ability to multitask, most of us evolved right along with our PCs, quickly learning to run multiple programs and work on several projects simultaneously. One thing that didn't change, though, was the basic amount of Desktop space available. Sure, larger monitors are available today than in the pre-multitasking days, but still, it seems that there is never enough space to see all your important data simultaneously. A multimonitor system is one way you can get around the not-enough-Desktop-space blues.

Goal

We set out to build a simple-to-configure-and-use system that would incorporate not one but two monitors. Our system needed to be adaptable, with software that would let us configure our displays the way we liked because we planned to use the dual-monitor system for a variety of applications.

Although it would have been easier to fit two LCDs on a desktop than two CRT monitors, we decided early on that we would build our dual-monitor system with CRTs. This way, we could keep costs down and build one of the most cost-effective systems possible. For your own dual-monitor system, you may want to use space-saving (but costlier) LCDs instead.

We also decided that we would build our computer from scratch, but it is very easy to convert an existing PC into a dual-monitor system by simply adding a video card and a spare monitor. We will discuss this option in greater depth later.

Background

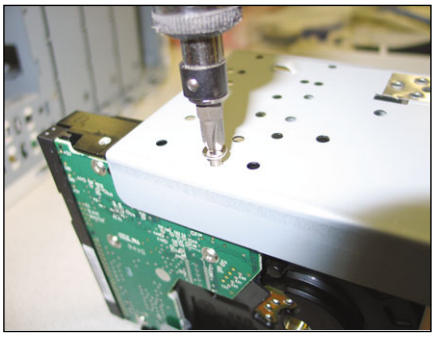
There were two ways we could have handled the video cards for our system. The first was to buy a special dual-monitor (also known as a dual-head) video card designed for attaching two monitors to the same PC. The second way was to buy two separate video cards and install both in our PC. We originally planned to buy two separate video cards, but we found a good deal on a Matrox Parhelia 128MB DDR video card and decided to buy it. One reason we liked the Parhelia card was that it came with software that made configuring a multimonitor setup easy. The other reason was that we planned to build a triple-monitor system next (see "How To Build A Triple-Monitor System" on page 84), and the Parhelia card could provide triple-monitor support.

If you would like to install multiple video cards instead, you can. However, if one of the video cards is an AGP card, keep in mind that your system only has one AGP slot, so the other video card must be a PCI card.

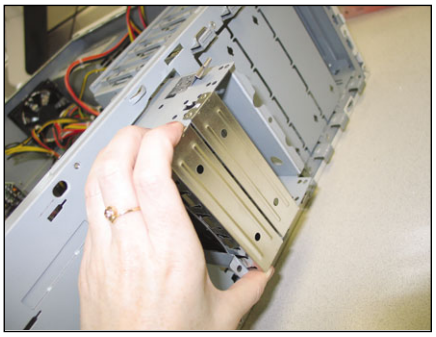
We chose a motherboard that could provide a well-rounded set of features yet provide plenty of room for upgrade options. The reason we did this is that there are many uses for a dual-monitor system and we wanted to build a system that you could upgrade or alter as needed to fit your needs. We chose the ASUS P4S800D-E Deluxe motherboard, which supports up to 4GB of dual-channel memory, up to eight Hi-Speed USB 2.0 ports, and a FireWire port. It also has an AGP 8X slot and five PCI slots, providing plenty of slots for adding video cards (and more monitors) in the future. If you don't need all the glamour of the P4S800D-E Deluxe board, you can save some cash and select any motherboard compatible with your video card or cards.

We rounded out the system with an Intel 2.8E GHz P4 processor, an 80GB hard drive, and 512MB of PC3200 DDR SDRAM. Depending upon how resource-intensive your computer work will be, you may want a faster processor, a higher-capacity hard drive, or more memory. If you need to save money, you can get a slower CPU or slower memory, such as PC2700 DDR. We found a reasonably priced Sony 52X/32X/52X/16X DVD-ROM/CD-RW combo drive and added it to our system.

We got a great deal on Windows XP Home by buying a copy that shipped with Service Pack 1. It was an SP1 close-out deal just before Microsoft released SP2. We chose WinXP, but Win98/Me/2000 also support multimonitor



We inserted the hard drive into the bay and used four screws to hold the drive in the bay.



The drive bay slid back into place and locked into position.

We attached an IDE cable to the Primary IDE slot on the motherboard.

configurations. You can only use Win95/NT for a dual-monitor system if your video card provides legacy drivers.

The Build

We will describe the process of building our entire system, but if you want to convert an existing PC into a dual-monitor system, you can gloss over much of this section of this article. Pay close attention to the "Video card installation," "Attach the monitors," and "Configure the multimonitor settings" sections, which detail the steps you should take to upgrade an existing PC.

Processor & heatsink installation. We started work on our system by carefully unpacking the motherboard from its box. We placed it on the antistatic bag in which it came, providing its components with some added protection as we worked.

First, we installed the CPU. We were careful to make sure that the processor was properly aligned with the socket on the motherboard before gently dropping the CPU into place. Ideally, you should only need to align the pins of the CPU with the holes of the socket and should not need to apply pressure to the processor for its pins to slide down into the holes of the socket. If you need to give the CPU more than just a nudge, check to ensure that the pins are aligned properly with the socket. We did need to gently nudge the processor into place, but because P4s have been notorious victims of bent pins, we were very careful. Once the processor was safely in its socket, we gently pulled the small lever of the socket down, locking the CPU in place.

Next, we installed the stock Intel fan. If you buy a retail CPU, a heatsink should come with it; if you buy an OEM processor, you will probably need to buy your own third-party heatsink. Heatsink installation varies by model, so check the documentation before installing yours. The hardest part of installing our heatsink was that we had to pull one of the fan's hooks out just a little bit before it would latch over the bracket that surrounds the socket. Once all four corners of the heatsink were clamped, we pressed the levers on top of the heatsink to secure the fan in place. The metal pieces of the heatsink caught the bracket on the motherboard, so we had to adjust things a bit before we could lock the fan in place. Next, we consulted our motherboard manual and plugged the fan's power connector into the proper jumper on the motherboard.

Motherboard installation. Next, we opened the case as directed in the case's

Multimonitor Software

Some of the most useful applications of a dual-monitor system require no special software at all. For instance, you might want to place a main application window on one monitor and the program's toolbars on the second monitor. You may also like to compare two documents side-by-side. The uses for a dual-monitor system are limited only by your own imagination. However, there are many programs especially designed for multiple monitors.

Realtime Soft's UltraMon ($39.95; www.realtimesoft.com) is a handy utility for configuring multimonitor systems. The program lets you customize your multimonitor display. For instance, you can clone one image on all monitors, stretch one image across all monitors, set specific applications to automatically load on a preconfigured monitor, and stretch Desktop wallpaper and screen savers across all monitors. Realtime Soft also publishes UltraMon VideoSaver ($19.95), which plays AVI, MPEG, QuickTime, and Windows Media files as multimonitor screen savers.

Silicon Realms Toolworks' MultiDesk ($25; siliconrealms.com/mdeskinfo.shtml) is another application for configuring a multimonitor system. Its unique feature is that you can lock and password-protect individual displays.

Finally, Microsoft's familiar PowerPoint ($229; www.microsoft.com/office/powerpoint) application supports multimonitor systems. You can view your notes and the thumbnails of upcoming slides on one monitor while displaying the full-screen presentation slides to your audience.

For more multimonitor-compatible programs, see the "Multimonitor Software" sidebars on page 87 of "How To Build A Triple-Monitor System" and page 91 of "How To Build A Quad-Monitor System." ▲

users guide. For our Enlight case, we pulled the front panel toward us until it popped off, revealing the screws that hold the case's side panels in place. After removing the screws from the left panel, we slid the panel off and then set the case on its side for easier access to its internal components.

Because our motherboard had more built-in ports than the Enlight case had port openings, we carefully but firmly pressed on the case's port backplane from inside the case until it popped out of place. Then we lined the ASUS-provided backplane up with the opening inside the case and pressed until the new backplane locked into place.

To provide added support for the motherboard, we twisted several small standoffs (provided with the case) into the inside of the case on the right panel. We placed these to line up with the screw holes in the motherboard. We could tell which way the motherboard went in the case by lining the mouse, keyboard, audio, monitor, and other ports on the motherboard up with the backplane's openings. We tilted the motherboard slightly, inserting the back side (with the ports) first. After threading the ports through the holes of the backplane, we carefully set the motherboard inside the case and used the supplied screws to secure it to the inside of the case. Then we connected the power supply's large power cable to the motherboard.

Front-panel buttons & LEDs. Next, we connected the small wires attached to the front of the case to the proper spaces on the motherboard. These wires were labeled, with one for the reset switch, one for the power LED, and one for the hard drive LED. The jumpers were labeled on the motherboard and in the users manual.

Video card installation. The Matrox Parhelia 128MB DDR dual-head video card is an AGP card, so we carefully pressed on the inner side of the backplane for the AGP slot until it popped off. Next, we lined the video card up with the AGP slot, making sure that the video ports were lined up with the now-open AGP backplane. We carefully but firmly pressed the video card into the AGP slot. We secured the video card's metal bracket to the side of the case with a screw.

Hard drive installation. Next, we connected the hard drive. First, we checked the case's documentation to see which bay was for the hard drive. For Enlight's case, we had to pull the hard drive bay out of the front of the case. This box holds the hard drive and can also hold additional hard or floppy drives.

We gently pried a metal plate off the front of the box to reveal the spot where the hard drive would reside. Then we slid the hard drive into the back end of the bay and made sure the screw holes in the hard drive lined up with those on the side of the bay. We used four screws to secure the drive in the bay and then we slid the bay back into the front of the case until the clamps on the side of the bay locked into place in the case.

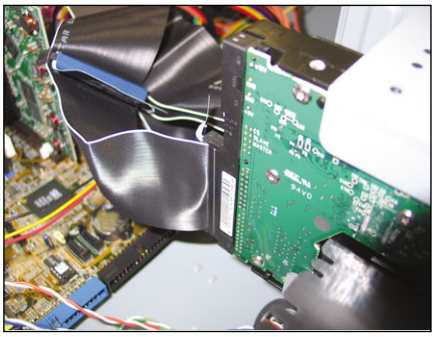
We connected one end of an IDE cable that came with our motherboard to the Primary IDE slot on the motherboard and the other end of the cable to the back end of the hard drive. We provided power to the hard drive by connecting one of the power supply's cables to the back of the hard drive.

Combo drive installation. Our case required that we slide a couple of brackets out from the side of the case before we could install the DVD drive. We pressed the combo drive until the case brackets clamped into place and clasped the drive. We let the drive protrude from the front of the case just slightly because when we reattached the front panel of the case, we wanted it to be flush with the front of the drive. Next, we

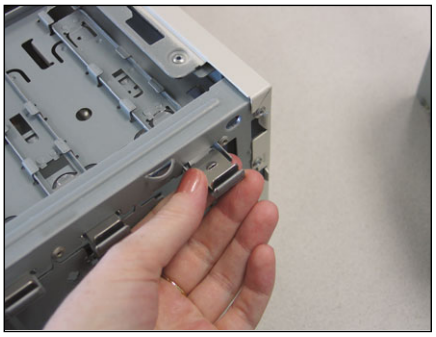
System Notes	
Height	18.9 inches
Width	7.5 inches
Depth	16.7 inches
Weight	25.43 lbs without monitors
Other Physical Details	Each monitor is 14.3 inches high x 16.2 inches wide x 16.4 inches deep and weighs 34.17 lbs.
Feature Set	
Outstanding Features	Supports up to 800MHz FSB, includes Gigabit Ethernet, motherboard supports RAID 0/1/10, supports FireWire and Hi-Speed USB 2.0, includes a 2.8GHz CPU, and has two 17-inch CRT monitors.
Weak Links	CRT monitors take up a lot of space, and the dual-head video card costs more than two standard video cards would have. We also could have picked a prettier case.
Performance	
3DMark03	978
PCMark04	4047

Parts List

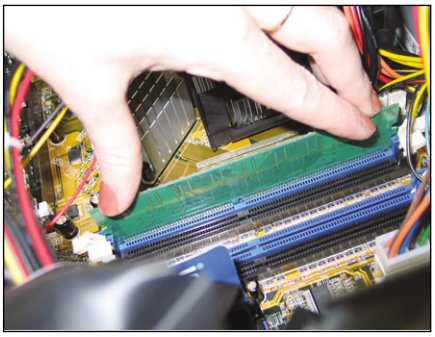
Component	Model	Price	Notes
Case	Enlight Mid-Tower ATX Case With 360W Power Supply, Model EN-7250 (Retail)	$53	
Power Supply	360W Power Supply	$0	Included With Case
Motherboard	Asus P4S800D-E Deluxe	$100	
Processor	Intel Pentium 4 2.8E GHz 800MHz FSB, 1MB L2 Cache, HyperThreading Technology (Retail)	$176	
Memory	Kingston PC3200 DDR400 512MB Kit	$106	
Hard Drive	Western Digital 80GB 7200RPM IDE Hard Drive, Model WD800BB (OEM)	$67	
Video Card	Matrox Parhelia 128MB DDR (PH-A8X128)	$342	
Sound Card	Built Into Motherboard	$0	
Network Card	Built Into Motherboard	$0	
DVD/CD Drive	Sony Beige 52X/32X/52X/16X Combo Drive, Model CRX320E (OEM)	$43.99	
Monitor	CTX VL700 17-inch CRT Monitor (Retail) - $87 each	$174	
Keyboard	KBTEK MCK-600-02 Keyboard PS/2 107 Keys (OEM)	$5.49	
Mouse	Logitech SBF96 Optical Wheel Mouse PS/2 (OEM)	$9	
OS	Windows XP Home	$89	Windows SP1 Clearance
Total		**$1,165**	



We connected the other end of the Primary IDE cable to the back of the hard drive.



Before adding the DVD drive, we had to slide a pair of brackets out from inside the drive bay.



We installed a memory module in each of the blue DIMM slots.

connected one end of an IDE cable to the Secondary IDE slot and the other to the back of the DVD drive and attached a power connector to the back of the device.

Memory installation. The memory was the last internal component we had to install. According to the motherboard manual, we could install the memory in either the blue or yellow DIMM slots. Interestingly enough, there were no yellow DIMM slots, only blue and black. We chose the blue slots and installed one module in each of the two blue slots. We pressed the white clamps on the end of each DIMM slot into the unlocked position, positioned a memory module in the slot, and then pressed the module until the plastic clamps snapped back up against the memory.

Add the video adapter. Matrox provided an adapter to connect to the port for the primary monitor (the monitor that will display the Windows startup screen). We simply pressed the adapter into the first of the two video ports on the back of the PC and then turned the screws of the adapter to ensure that it stayed connected.

Attach the monitors. We set the left panel back on the case, screwed it in place, lifted the case upright, and snapped the front panel back on. We used a supplied video cable to connect one monitor to the video adapter we just installed and the other to the open port on the AGP card. We then screwed the video cable's screws to secure the monitors' connections. Finally, we plugged both of the monitors and the PC into our surge protector, started up the system, and installed Windows.

Configure the multimonitor settings. After installing Windows, we ran the installation disc that came with our video card. When we installed the drivers, a wizard prompted us to answer a few questions about the number and type of displays we would use. Detailed instructions for connecting the monitors appeared on-screen. This is a valuable tool, especially if you plan to set up a less-conventional multimonitor configuration.

After we installed the driver and restarted the system, the software walked us through monitor configuration. Each of our monitors displayed a letter in the upper-left corner. A dialog box on-screen asked if the letters were in alphabetical order. Our monitors were in the right order, so we clicked Yes and let the wizard guide us through the rest of setup.

If we had used two single-monitor video cards instead of our dual-head Matrox card, we would have clicked the Start Menu, Settings, and Control Panel and then double-clicked Displays to access the multimonitor settings. Windows works similarly to the Matrox software, except that it creates a graphical, labeled representation of your monitors and prompts you to drag and drop the monitors into the proper positions.

Testing

It was exceptionally easy to configure our monitors with the utilities that came with the Parhelia video card. We could stretch the display across both monitors or clone the same image on both monitors. Almost every application we ran was easier to navigate thanks to the second monitor we'd connected. We moved toolbars out of the way of documents. We ran two applications side-by-side.

Furthermore, our system ran fast, making it a good PC for a variety of tasks. We are especially intrigued by the idea of editing photos or video, but we would probably choose higher-end monitors if we were to use our dual-monitor computer for this purpose.

We ran FutureMark's 3DMark03 and PCMark04 benchmarks on our dual-monitor system. The scores were 978 3DMarks and 4047 PCMarks, with the highest scores coming from the memory and CPU tests.

Final Remarks

The only thing we really didn't like about this system was how cramped it made our work area. While we gained more Windows Desktop space, we lost a lot of desktop furniture space. To get around this problem, we could either buy LCD monitors instead or we could invest in a monitor-mounting device. For more information about these devices, see the "Monitor-Mounting Hardware" sidebar on page 86 (part of our article on triple-monitor systems).

Other than the desktop space issue, we really enjoyed building, setting up, and using our dual-monitor system. After only a few hours using two monitors, we were spoiled. It was hard to go back to toggling between windows and staring at just one monitor again. If you'd like to add a second monitor to your PC, this is one of the simplest upgrades you can make. RS

by Kylee Dickey

How To Build A Triple-Monitor System

Make Room For More Windows

Build #20 Skill Level: 1 **2** 3 4 5 ***Apprentice***

Once we built a dual-monitor system (see "How To Build A Dual-Monitor System" on page 80), it seemed like a natural progression to add a third monitor. We could use a triple-monitor system for many of the same applications as a dual-monitor system, but three displays would give us even more options for boosting our productivity.

Goal

Once again, our goal was to build a cost-effective multimonitor system. This time, however, we spent a bit more money, opting for LCD monitors rather than CRTs. The main reason we did this was to preserve precious desktop space. Three CRTs would consume more space than we had.

Background

There are many reasons to build a triple-monitor system. One example is for use as an HTML-coding machine. You could have your text editor on the center screen, Internet Explorer on the left screen, and another browser, such as Mozilla, on the right screen. As you worked, you could refresh the views and compare the way your Web page displays in each browser. Triple-monitor systems are also excellent for viewing panoramic images. One of the most compelling excuses to build a triple-monitor system, though, is the promise of surround gaming. Read more about surround gaming in the "Multimonitor Software" sidebar on page 87.

We built our own PC from scratch, but you could simply add a pair of video cards and monitors to your existing computer. The main advantage of our Matrox Parhelia video card is that it comes with software that makes it very easy to configure a triple-monitor system. The Parhelia is a dual-head card (support for two monitors). It supports the third monitor through a Y-adapter that comes with the video card.

We selected three identical 15-inch LG Electronics L1515S LCD monitors, mainly because they were some of the more affordable yet decent LCDs we found. You do not need to use identical monitors; we bought three of the same monitor so our displays would line up in a row neatly. You can use almost any combination of monitors, but if you use a multimonitor video card, check with the manufacturer to ensure that it supports the combination of analog, digital, and TV displays that you intend to use.

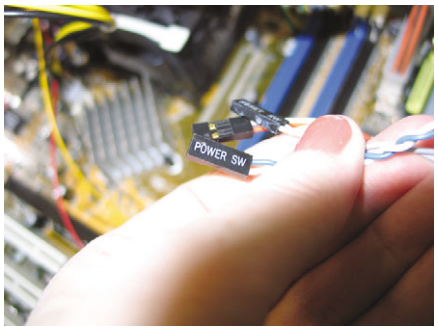
The other components we chose were not essential to a triple-monitor system, so we chose them with the goal of creating a well-rounded system that would perform well and leave room for upgrades. The Asus P4C800-E Deluxe motherboard has a number of advanced features, such as 800MHz FSB support and FireWire and Hi-Speed USB 2.0 support. (Incidentally, this is also a highly overclockable board, although that didn't factor into our triple-monitor system at all.)

Finally, we added an Intel 2.8E GHz P4, an 80GB 7,200rpm hard drive, 512MB of PC3200 DDR, and a Sony 52X/32X/52X/16X DVD-ROM/CD-RW drive. If you build your own system, you can upgrade or downgrade any of our selections and build a triple-monitor system.

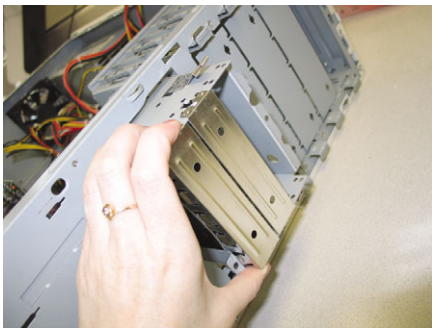
The Build

We won't go into detail about building this system because all of its components, except for the monitors, are the same as those of the dual-monitor system we built. What follows is a brief account of how we built our system.

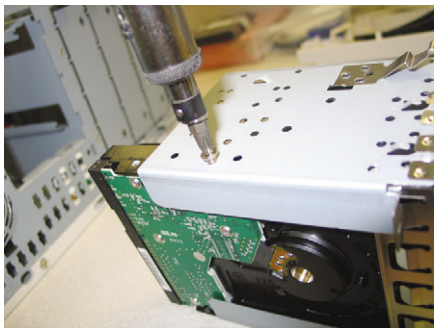
System Notes	
Height	18.9 inches
Width	7.5 inches
Depth	16.7 inches
Weight	25.43 lbs without monitors
Other Physical Details: Each monitor is 12.52 inches high x 13.78 inches wide x 5.24 inches deep and weighs 5.95 lbs.	
Feature Set	
Outstanding Features: Supports up to 800MHz FSB, includes Gigabit Ethernet, motherboard supports RAID 0/1/10, supports FireWire and Hi-Speed USB 2.0, includes a 2.8GHz CPU, and has three 15-inch LCDs.	
Weak Links: The multimonitor video card was a little bit costly, but you can cut costs by using either three individual video cards or one dual-head card and one standard video card.	
Performance	
3DMark03	978
PCMark04	4047



The switch and LED connectors from the front of the case need to connect to the motherboard.



The drive bay slid back into the case very easily.



We used four screws to hold the hard drive in the drive bay.

We started by installing the Intel P4 processor in its socket. We then hooked the clamps on the side of the stock Intel fan (which came with our processor) to the hooks on the bracket surrounding the socket. This required some effort, as one of the corners didn't want to latch in place at first. With some gentle nudging, we secured the clips on the heatsink. We then connected the fan's power cord to the proper socket.

Once the CPU and fan were in place, we opened the Enlight case and placed it on its side. We then replaced the standard backplane with the ASUS P4C800-E Deluxe's custom backplane. Next, we twisted standoffs into the case to support the motherboard where needed, ensuring that each standoff would be positioned underneath one of the screw holes when we placed the motherboard in the case. Then we lowered the motherboard into the case, threaded the ports through the corresponding backplane openings, and secured the motherboard to the case using screws. We pressed the large power connector from the power supply to the motherboard in the socket illustrated in ASUS' users manual. We also connected the reset switch, power LED, and hard drive LED connectors.

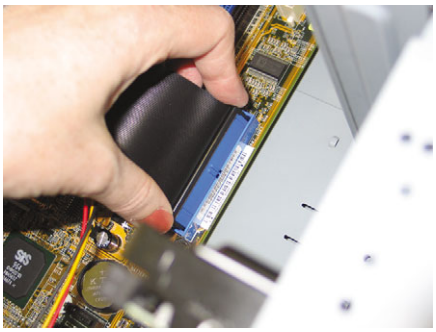
To install our Matrox Parhelia 128MB DDR dual-head AGP video card, we removed the backplane for the AGP slot and pressed the video card into the slot and locked it into place. We also secured a screw to the card's bracket at the back of the case.

We inserted the hard drive and DVD drive into the proper drive bays as detailed in our case's documentation. We used screws to connect the drives to the bays, and we connected an IDE cable from the Primary IDE slot to the hard drive and another IDE cable from the Secondary IDE slot to the DVD drive. We also attached a power connector to the back of each of the drives.

Finally, we installed our 512MB DDR SDRAM kit. According to the motherboard manual, we could install the memory in either the blue or yellow DIMM slots. Interestingly enough, there were no yellow DIMM slots, only blue and black. Because we knew the blue slots were safe to use, we installed each memory module in one of the two blue DIMM slots. This memory module required a little bit more force than most that we've installed in the past, so we had to press down quite firmly. We then followed the same procedure to install the second memory module in the other blue DIMM slot.

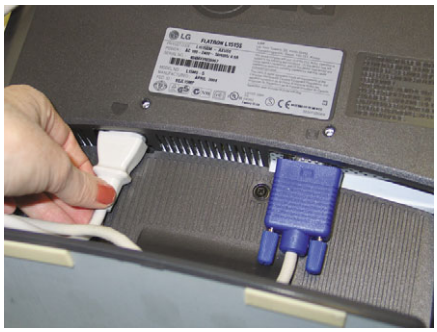
At this point, our computer was almost finished. We still needed to connect an adapter that came with the Matrox video card. This adapter connects to one of the monitor ports and tells the card to treat the connected monitor as the primary display. The primary monitor is the one that will display the Windows startup screen when you start the system. We pressed the adapter into the first of the two monitor ports and then we tightened the screws of

Parts List			
Case	Enlight Mid-Tower ATX Case with 360W Power Supply, Model EN-7250 (Retail)	$53	
Power Supply	360W Power Supply	$0	Included with case
Motherboard	ASUS P4S800D-E Deluxe	$100	
Processor	Intel Pentium 4 2.8E GHz 800MHz FSB, 1MB L2 Cache, HyperThreading Technology (Retail)	$176	
Memory	Kingston PC3200 DDR400 512MB Kit	$106	
Hard Drive	Western Digital 80GB 7,200rpm IDE Hard Drive, Model WD800BB (OEM)	$67	
Video Card	Matrox Parhelia 128MB DDR (PH-A8X128)	$342	
Sound Card	Built into motherboard	$0	
Network Card	Built into motherboard	$0	
DVD/CD Drive	Sony Beige 52X32X52X16 Combo Drive, Model CRX320E (OEM)	$43.99	
Monitor	LG Electronics L1515S 15-inch LCD Monitor (Retail) $298 each	$894	
Keyboard	KBTEK MCK-600-02 Keyboard PS/2 107 Keys (OEM)	$5.49	
Mouse	Logitech SBF96 Optical Wheel Mouse PS/2 (OEM)	$9	
OS	Windows XP Home	$89	Windows SP1 clearance
Total		**$1,885**	



We attached an IDE cable to both the hard drive and the Primary IDE slot of the motherboard.

Matrox provided this video adapter, which will indicate which monitor is the primary monitor.



We connected both the data and power cables to the back of each of the three monitors.

the adapter to ensure that the adapter stayed in place.

Finally, we closed the case by reattaching the left panel and screwing it back in place. We also snapped the front panel back onto the case and set the PC upright again.

Attach the monitors. Finally, we were ready to unpack our new LCD monitors. A video cable and a power cable came with each monitor. Your monitor may have power or video cables that are permanently attached to the monitor. If so, you will not need to do anything at this point except set your monitor on the desktop. We connected the video cable to the video port on the back of the monitor by pressing it into place and then twisting the two screws until they were reasonably tight. Then we plugged the power cord into the back of the monitor. We connected each of the remaining two monitors the same way.

Next, we set the monitors on the desktop so that we could connect them to the back of the PC. You may want to use a special desktop stand or wall-mounting device to hold your monitors in the desired positions. You can learn more about multimonitor mounting devices in the "Monitor-Mounting Hardware" sidebar on this page.

After setting our monitors up in the desired positions, we connected the first monitor (the one we wanted to act as the primary monitor) to the primary monitor adapter on the back of the PC by inserting the cable into the adapter and then turning the screws until the cable was secured in place.

Next, we found the Y-cable Matrox sent with our video card. This cable would connect the second and third monitors to the second video port on the Parhelia video card. This cable was white at the base of the Y and blue at the two ends that connected to the monitors' video cables. One end was labeled 1 and the other end was labeled 2. We connected the video cable for the second monitor to the end of the Y cable labeled 1, and we attached the video cable for the third monitor to the end of the Y cable labeled 2. Then we connected the loose end of the Y cable to the second video port at the back of the PC. With everything else ready to go, we simply plugged the computer into our surge protector and then plugged each of our three monitors into the surge protector.

Configure the multimonitor settings. After installing Windows on our system, we inserted and ran the installation disc that came with our video card. When we installed the drivers, a wizard prompted us to answer a few questions about the number and type of displays we would use. Detailed instructions for connecting

Monitor-Mounting Hardware

As we added more monitors, we realized that space was a valuable resource. There are a variety of mounting devices available to help you not only free desktop space but also properly display your monitors in a multimonitor configuration.

For instance, Consul, JetMaster, and Spacedec all make stands and arms that hold LCDs in place. You can buy multiple individual adjustable stands, or you can buy a stand that is designed especially for multimonitor configurations. A multimonitor mounting device often holds the monitors in a specific arrangement but allows for some ergonomic adjustment. Other multimonitor mounting devices having swiveling or hinged arms that let you arrange the monitors as you like.

One of the companies that makes such stands and mounts is Atdec (www.atdec.com), which manufactures mounts that screw into the wall, desktop stands, and systems with swiveling arms for adjusting the LCD position. Atdec's Spacedec products mount LCDs on adjustable arms. Visidec stands hold LCDs in place on top of a desk and have spring-assisted height adjustment and a swiveling base. Telehook products mount to the wall. Finally, if you want to mount a group of CRT monitors on the wall, Atdec offers Teledec wall-mounting brackets for TVs and CRTs.

Some mounting devices hold individual monitors, while others have several arms to hold multiple monitors. A quick online search for multimonitor stands or multimonitor mounts produces many sites where you can buy such accessories, including www.lcdmonitorarm.com, www.ladybugelectronics.com, and www.ergotron.com. Expect to make a considerable investment, however. Monitor-mounting devices often cost about the same amount as the monitors themselves. ▲

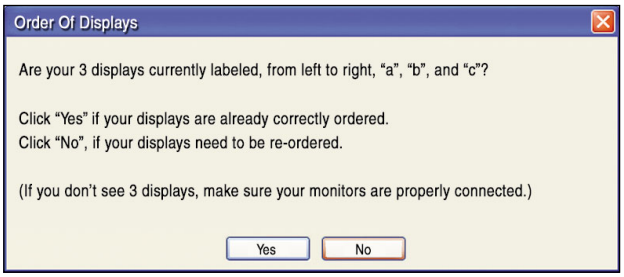
the monitors for the type of system we selected then appeared on-screen. This is a valuable tool, especially if you plan to set up a less-conventional multimonitor configuration than we did.

After we installed the driver and restarted the system, the software walked us through the configuration process. Each of our monitors displayed a letter in the upper-left corner. Initially, our monitors were labeled b, c, and a, in that order. A dialog box on-screen asked if the letters were in alphabetical order. We clicked No. This launched a configuration wizard that provided a list of possible arrangements of the letters a, b, and c. We found b, c, a on the list and selected it. This way, the system knew how we had arranged our monitors and in what order it should display segments of the various windows and the Desktop.

Testing

We had no problem configuring our three displays using the utilities that came with our Matrox Parhelia video card. It was simple not only to initially configure our system but also to quickly change the way in which the three monitors displayed video. This made it easy to change our display setup, according to the type of software we wanted to use.

We were also relieved that all three of our LCDs worked very well out of the box. If you find that your monitors interfere with each other, though, you may need to move the monitors farther apart or use the Windows Control Panel to set different refresh rates for the monitors. You can also insert a shielding material between your monitors to lessen interference. We did not have to make any changes to either the hardware or software configurations of our system after the initial setup.


Order Of Displays
Are your 3 displays currently labeled, from left to right, "a", "b", and "c"?
Click "Yes" if your displays are already correctly ordered.
Click "No", if your displays need to be re-ordered.
(If you don't see 3 displays, make sure your monitors are properly connected.)
Yes
No

The software helps you configure the order and layout of the monitors.

One of our favorite ways to use the triple-monitor system was to open Internet Explorer on the left monitor, Word on the center monitor, and Outlook on the right monitor. This way, we could conduct research on the left monitor as we typed on the center monitor. We could also quickly check the right monitor for new email messages.

The triple-monitor display was also especially well-suited for photo editing. We placed the original photo on the left monitor, the version we were editing on the center monitor, and the photo-editing toolbars on the right monitor. This let us access toolbars and compare the original photo to the edited version without ever toggling among windows or dragging toolbars out of the way.

Applications loaded and ran quickly, but we ran a few benchmarks to get a more objective feel for how the system operated. We got a decent 3DMark03 score of 978, but it was PCMark04 that really returned the impressive test results. Our triple-monitor system managed 4047 PCMarks, with CPU, Memory, Graphics, and Hard Drive scores of 4235, 4590, 2643, and 3780, respectively.

Final Remarks

For as much as we enjoyed using our dual-monitor system, the triple-monitor configuration was even more fun. With the monitors spread out in front of us, it was easy to get immersed in either work or play with this system. If you would like to build a similar system but want to cut costs, consider going with at least one CRT monitor. You can mix and match CRTs and LCDs to achieve a configuration that fits on your desktop and meets your budget. RS

by Kylee Dickey

Multimonitor Software

There are a number of programs designed specifically for use on a multimonitor system. We covered some of these in the last article (see "How To Build A Dual-Monitor System" on page 80) and will cover a few more in the next article (see "How To Build A Quad-Monitor System" on page 88), but here are a few more programs that take advantage of multiple monitors.

One of the most common types of programs for triple-monitor displays is games. Surround gaming is to video games what surround sound is to movies. When you play a surround game, the action wraps around you. You will find triple-monitor support for action games such as Raven Software's StarTrak Voyager: Elite Force ($19.99; www.ravensoft.com), but you will also find calmer surround games, such as Slightly Subtle Technology's Dogs Playing Poker ($9.99; www.dogsplayingpoker.tv). Set your monitors up across the table from you, and it will look like you are really playing poker with a group of dogs. A list of other games with triple-monitor support is available at www.matrox.com/mga/3d_gaming/surrgame.cfm.

gPhotoShow2 (11.95 euros [approximately $16]; www.gphotoshow.com) lets you design your own screen savers from your digital images. It can display photos (the same photo or different photos) on each monitor, whereas most screen savers either do not work at all with a multimonitor configuration or appear on only the primary monitor.

We've seen the Matrix Code Emulator screen saver (freeware or customizable edition for $3.99; www.realityrift.com), but we hadn't realized before that this screen saver supports multimonitor displays. This screen saver scrolls the Matrix code on multiple monitors, just like in the movie. ▲

How To Build A Quad-Monitor System

Help! Our Monitors Are Multiplying!

Build #21 Skill Level: 1 **2** 3 4 5 *Apprentice*

We had already built a dual-monitor system and a triple-monitor system. Now we were ready to build the largest multimonitor system we could without running out of room for monitors. We were about to connect four displays to a single system. Quad-monitor systems are useful mainly for professionals who require expansive Desktop space and side-by-side comparison of multiple documents. However, anyone who has the space for four monitors can really benefit from a quad-monitor system.

Goal

Our goal was to build a quad-monitor system that would consume little enough space to be functional for the average user. We wanted to build a system that would strike a good balance between ease of use and cost.

Once again, we decided to use LCDs rather than CRT monitors. We knew that space would be tight enough on our desktop if we bought four LCDs. We would have had serious space issues if we had bought four CRTs. If you need help finding space for your monitors, you could probably benefit from a multimonitor mounting system of some type. Learn more about multimonitor stands and mounts in the "Multimonitor Mounting Hardware" sidebar in "How To Build A Triple-Monitor System" on page 84.

Background

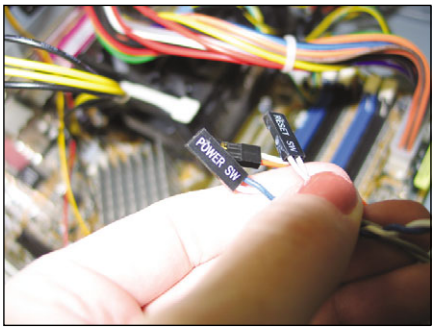
We could have used several varieties of configurations for this system. For instance, we could have installed four PCI video cards, one AGP video card and three PCI cards, two dual-head cards, one dual-head card and two standard cards, one dual-head card with triple-monitor adapter and one standard card, or one quad-head card. We bought a dual-head card for our previous multimonitor systems. The video card for those systems came with great software that walked us through setup and configuration, so we felt that it would be preferable to buy a quad-head video card rather than a combination of single-, dual-, or triple-head cards. We felt that the quad-head card would make setup as simple as it was for the dual- and triple-monitor systems. As we will discuss later, our plan backfired.

We could not simply use the same card that we had for the dual- and triple-monitor systems because it only supported up to three monitors. Had we decided to incorporate that card into our system, though, we could have added a PCI video card for the fourth monitor. Instead, we bought a Matrox Multi-Monitor Series G450 X4 MMS graphics card. This quad-head card supports up to four monitors natively, but the card is pricey (over $700), so if you go this route, be prepared to dish out a considerable sum of money.

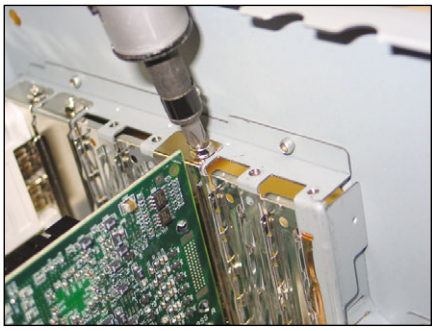
Although we built an entire PC, it would work just as well to add the appropriate video card (or combination of video cards) to an existing system and connect four monitors. We will walk through the process of building our entire system, but if you want to adapt a current PC for quad-monitor usage, you can skim over the following sections and then pay close attention to the parts about installing video cards and connecting and configuring monitors.

For our triple-monitor system, we used three identical 15-inch LG Electronics L1515S LCD monitors, so we simply bought one more L1515S LCD for this project. By using four identical monitors, we could line up all four in a row for a nice, even display, or we could mount the

System Notes	
Height	18.9 inches
Width	7.5 inches
Depth	16.7 inches
Weight	25.43 lbs without monitors
Other Physical Details: Each monitor is 12.52 inches high x 13.78 inches wide x 5.24 inches deep and weighs 5.95 lbs.	
Feature Set	
Outstanding Features: Supports up to 800MHz FSB, includes Gigabit Ethernet, motherboard supports RAID 0/1/10, supports FireWire and Hi-Speed USB 2.0, includes a 2.8GHz CPU,and has four 15-inch LCDs.	
Weak Links: The quad-monitor card wasn't as easy to configure as the video card for the dual- and triple-monitor systems was. Also, using a quad-monitor video card was much more expensive than installing multiple video cards. Finally, this video card does not have very good high-end graphics support, so this system shouldn't be used for video editing or games.	
Performance	
3DMark03	N/A
PCMark04	3259



We connected the power, reset, and LED connectors from the front of the case to the motherboard.



We used a screw to secure the PCI video card to the back of the case.

monitors in two rows of two LCDs each for a uniform, rectangular display. You do not need to select monitors of the same size for your system, however. Choose a selection of monitors that best meets your needs. If you want to do graphics editing on one monitor and basic computing tasks on the other three, you may want three smaller monitors and one large monitor.

We had complete freedom in picking the other components for our system, as you do not need a specific type of motherboard, a certain amount of memory, or anything else to build a quad-monitor system. We simply checked the Matrox G450 X4's requirements to ensure that the parts we bought supported the video card.

We chose an ASUS P4C800-E Deluxe motherboard, which offered a variety of ports, including Hi-Speed USB 2.0 and FireWire. We also chose a 2.8E GHz P4, an 80GB 7,200rpm hard drive, 512MB of PC3200 DDR, and a Sony 52X/32X/52X/16X DVD-ROM/CD-RW drive. As we mentioned, these parts are not essential to the overall build of the system, so you can alter these components as you please when you build your own quad-monitor system.

The Build

Except for the video card, we built the same basic system as we did for our dual- and triple-monitor systems. We'll describe the basic build process below, but if you want a more detailed account of assembling the components, see "How To Build A Dual-Monitor System" on page 80.

First, we inserted the Intel P4 processor in the socket on the motherboard and pulled the lever down, locking the CPU in place. We then placed the stock Intel fan that came with the processor over the processor and pulled its four clamps down until they clasped the bracket around the socket. The easiest way to do this was to connect two of the clamps first and then pull the two clamps on the other side of the processor down over the bracket. We connected the fan's power cord to the labeled socket on the motherboard.

Next, we opened the Enlight case and set it on its side. We pressed the standard backplane out and replaced it with the one that came with our ASUS motherboard. The ASUS backplane has additional openings for the motherboard's many ports.

Next, we twisted standoffs into the holes on the right panel of the case. We placed the standoffs in the holes that would lie underneath the screw holes in the motherboard. We set the motherboard in the case, threading its ports through the backplane openings before setting the motherboard completely down on the standoffs. We then used the supplied screws to secure the motherboard to the standoffs and case.

We followed the instructions that came with the motherboard and case to attach the main power, reset switch, power LED, and hard drive LED connectors to the appropriate sockets of the motherboard.

When we built the dual- and triple-monitor systems, we installed the Parhelia video card in the AGP slot. The Matrox

Parts List

Case	Enlight Mid-Tower ATX Case with 360W Power Supply, Model EN-7250 (Retail)	$53	
Power Supply	360W	$0	Included with case
Motherboard	ASUS P4S800D-E Deluxe	$100	
Processor	Intel Pentium 4 2.8E GHz 800MHz FSB, 1MB L2 Cache, HyperThreading Technology (Retail)	$176	
Memory	Kingston PC3200 DDR400 512MB Kit	$106	
Hard Drive	Western Digital 80GB 7,200rpm IDE Hard Drive, Model WD800BB (OEM)	$67	
Video Card	Matrox Multi-Monitor Series G450 X4 Graphics Card (G450 X4 MMS)	$740	
Sound Card	Built into motherboard	$0	
Network Card	Built into motherboard	$0	
CD Drive	See below		
DVD Drive	Sony Beige 52X/32X/52X/16X Combo Drive, Model CRX320E (OEM)	$43.99	
Floppy Drive	N/A		
Monitor	LG Electronics L1515S 15-inch LCD Monitor (Retail) $298 each	$1,192	
Speakers	N/A		
Keyboard	KBTEK MCK-600-02 Keyboard PS/2 107 Keys (OEM)	$5.49	
Mouse	Logitech SBF96 Optical Wheel Mouse PS/2 (OEM)	$9	
OS	Windows XP Home	$89	On sale. Clearing out SP1 before SP2 release
Total		**$2,582**	

G450 X4 card, however, is a PCI card. Regardless of what type of video card you install, it is essential that you install it in the proper slot to avoid damaging the card or motherboard. AGP and PCI cards look different and will not fit into each others' slots. Our video card's users manual clearly stated that to avoid damaging the card, we should install it in the PCI slot.

To install the card, we first removed the backplane that corresponded to one of the open PCI slots. We lined the G450 card up in the slot and pressed carefully but firmly until the card slid into place in the slot. We also used a screw to attach the card's backplane to the back of the case.

Next, we pulled the hard drive bay out of the front of the Enlight case. We also removed a metal plate from the front of the bay. This revealed the space where we would install the hard drive. We slid the drive into the bay from the back, lined the screw holes of the bay up with the screw holes in the hard drive, and then used the supplied screws to secure the drive in the bay. We slid the bay back into the front of the case until clamps on the side of the bay clasped the drive bay. We connected one end of an IDE cable to the Primary IDE slot on the motherboard and the other end of the cable to the back of the hard drive. We also attached a power connector to the back of the drive.

To install the DVD drive, we had to slide a pair of brackets out so that they protruded from the inside of the case. Then we lined the DVD drive up with the brackets and pressed it into the case until the brackets clamped onto the drive. We pressed the drive in most of the way but let it stick out just enough so that the front of the drive would be flush with the front of the case when we replaced the case's front panel. The hard drive would be the primary drive, and the DVD drive would be the secondary drive, so we connected one end of an IDE cable to the Secondary IDE slot of the motherboard and the other end of the cable to the back of the DVD drive. Then we located one of the power supply's power connectors and attached it to the back of the DVD drive.

The last components we installed were the two memory modules. We installed one module in each of the blue DIMM slots. We pressed each of the modules into the slot until the clamp on the slot popped up and grasped the ends of the memory module.

Connect the monitors and install software. We closed the case and set it upright, and then we attached the two Y-cable adapters that came with our Matrox G450 video card. Each of these adapters plugged into one of the Matrox card's two video ports. We pressed the adapters into the ports firmly and then tightened the screws of the adapters to ensure that the cables were securely attached.

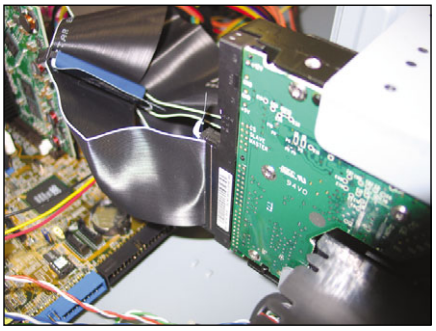
Next, we unpacked each of our four LCD monitors and arranged them in the desired pattern on the desktop. We chose to arrange our monitors in a straight line, ideal for viewing very wide windows or panoramic images. Each monitor came with a video cable, which we connected to the back of the monitor and tightened in place with the cable's screws. Next, we connected each of the four video cables to an end of one of the Y-adapters that we had plugged into the computer's video ports. When we built our triple-monitor system, the adapters were labeled so that we knew which monitor to plug into which connector. There were no such labels on the quad-monitor system, so we simply plugged one monitor into each connector. We would use the Windows Control Panel later to tell the system how the monitors were arranged on the desk.

Finally, we connected the keyboard and mouse to the back of the PC, plugged in the computer, and plugged in each of the four monitors. We started up the computer, installed Windows, and ran Windows Update.

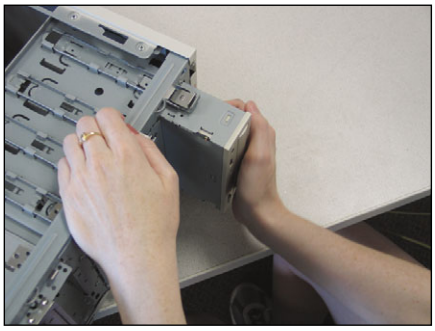
Configure the multimonitor settings. After installing Windows on our system, we inserted and ran the installation disc that came with our video card. We followed the on-screen instructions to install the driver and then restarted the computer.

We had expected a configuration wizard similar to the one that guided us through the dual- and triple-monitor setup with our Matrox Parhelia card, but the G450 video card offered no such guidance. After installing the driver, there was no wizard at all and instead, we had to access the display settings in Windows' Control Panel. To do this, we clicked the Start menu and Control Panel. Then we double-clicked Displays and clicked the Settings tab. A graphical representation of the monitors appeared in the dialog box. Each of the monitors shown in the dialog box was numbered

We connected an IDE cable to the Primary IDE slot of the ASUS motherboard.



We connected the other end of the primary IDE cable to the back of the hard drive.



We pressed the DVD drive into the case until it snapped into the drive bay brackets.

(1, 2, 3, and 4). We clicked the Identify button, and Windows displayed a number (1, 2, 3, or 4) on each of the four monitors. We then clicked and dragged the four numbered monitors on-screen until they were aligned in the same order as the physical monitors on our desktop. Then we clicked the OK button. This was not quite as easy as using the wizard that came with our other Matrox card, but it worked well nonetheless.

Testing

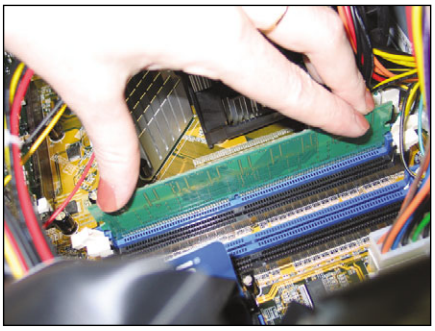
Although the Matrox G450 video card was not too difficult to configure, we were disappointed that it did not provide wizards similar to those of the Matrox Parhelia card we used in the dual- and triple-monitor systems. Because we had to configure our monitors through the Windows Control Panel and did not have any special tools for customizing our quad-monitor display, we would probably save money next time around and build this system using two dual-head video cards or four standard video cards. We could set up the monitors in the same way using the Windows Display settings in the Control Panel.

We also noted that, although we could stretch individual application windows across all four monitors, the Desktop wallpaper did not stretch across all four screens as it did with the dual- and triple-monitor systems. Instead, the same Desktop wallpaper repeated on each of the four monitors. The Start menu, Taskbar, and System Tray all appeared only on the primary monitor. This was not a problem to troubleshoot; it is just that the G450's driver didn't stretch the wallpaper and Taskbar across all screens as the Parhelia's driver did. This was not even possible using the most current drivers available for the G450 at press time.

Despite some differences between our triple- and quad-monitor displays, our quad-monitor system still worked very well. We could open windows on different monitors, isolate programs to specific displays, and even stretch a single application window across all four monitors.

All four monitors worked well, and none had any dead pixels. We also had no interference among monitors, so the setup was very simple. We used the quad-monitor system to view and edit a few panoramic images. We also experimented with multitasking with four programs visible simultaneously, each in a separate window.

Although our triple-monitor system would have worked well for surround gaming, we would not endorse our quad-monitor system for gaming. The G450 video card was built for business use rather than gaming use. In fact, we could not run 3DMark03 on our quad-monitor system because it did not meet the requirements needed to run any of the four tests.



We inserted a memory module in each of the blue DIMM slots.

We could run PCMark04 benchmark, and the scores revealed quite a bit about our system. The overall score was 3259 PCMarks. Our quad-monitor system got high marks in both CPU and memory tasks at 4201 and 4578, respectively. The hard drive tests returned a decent score of 3968. The graphics tests hurt our system the most, with PCMark04 generating a score of 392.

Final Remarks

Our quad-monitor system will perform well if you want to have a view of several application windows simultaneously, or if you want to stretch individual windows across multiple screens. This PC is designed for basic computing, multitasking between monitors, and even basic image editing. It will not, however, be a good system for graphics-intensive applications such as video editing or gaming. If there is one thing that we would do differently next time, it would be to save some money by skipping the pricey Matrox quad-monitor video card and instead installing multiple graphics cards. Of course, although we may have saved some money, the quad-monitor video card did ensure that we would not have to troubleshoot PCI conflicts between video cards. RS

by Kylee Dickey

Multimonitor Software

We covered some of the multimonitor software available in the Multimonitor Software sidebars in "How To Build A Dual-Monitor System" on page 80 and "How To Build A Triple-Monitor System" on page 84. However, we still have one very important multimonitor application left to mention.

One of the best multimonitor programs available is EnTech Taiwan's PowerStrip ($29.95; entechtaiwan.net/util/ps.shtm). This utility includes a variety of display tools that you can use regardless of whether you have more than one monitor attached to your PC. However, one of the most important PowerStrip tools for multimonitor configurations is its monitor calibration tools. By using these tools on your multimonitor system, you can easily adjust each of the monitors so that each color appears the same on all monitors. PowerStrip not only helps you adjust colors but also brightness and contrast so that all of your monitors look like part of one unified system.

You can also use PowerStrip to configure your system so that each monitor behaves in predetermined ways. For example, when you launch a game, it may load on a specific monitor, with certain gamma settings, and with a specified refresh rate. When you launch a word processor, it may automatically load on a different monitor and with its own preset display configurations. PowerStrip is compatible with Windows 9x/NT/Me/2000/XP and with most graphics cards. ▲

RAID 0 Under $1,000

320GB Of Striped Fury

Build #22 Skill Level: 1 **2** 3 4 5 ***Apprentice***

"Man, who brought the slow guy?" Besides your Internet connection, your computer probably spends more time waiting for its hard drive than any other component.

Unfortunately, there isn't much you can do to make a single hard drive faster. Replacing it with a speedy SCSI drive intended for servers—and an adapter card to make it work in your computer—can cost you hundreds more. However, you *can* buy two or more identical, low-cost drives and use them together for a surprising speed boost.

This article kicks off our storage section in which we explore the world of multiple hard drives. More specifically, we show you how you can combine drives in interesting ways, such as for radical speed improvements, automatic data backup, or both. This is called making a RAID (redundant array of independent disks/drives), of which there are many kinds. We'll start with the popular RAID 0.

Goal

You can make a RAID 0 with two or more hard drives. RAID 0 writes to and reads from each drive at the same time, splitting data among them. This division of data, called striping, can mean about 50% more speed over a system with a single hard disk or multiple unRAIDed drives. Because hard drive speed is a major factor in how fast a computer "feels"—not in games or encoding, but in loading apps, documents, and game levels—a RAID 0 really steps up a PC's responsiveness for work or play.

Unlike real RAIDs, RAID 0 doesn't keep identical data or error-checking parity information on more than one drive. In other words, it offers the same capacity as two unRAIDed drives, such as 320GB for the two 160GB drives we bought for this PC. However, this lack of redundancy also technically disqualifies RAID 0 from being called a RAID, although the industry still does so.

Although this lack of fault tolerance allows RAID 0 to offer more total storage space than other RAID types, it's also RAID 0's weakness. A crash or flaw in either hard drive can make the data unretrievable on both drives, not just the bad one. In other words, a RAID 0 could be twice as likely to fail as a single drive. Keep a RAID 0 religiously backed up.

We cobbled together a respectable RAID 0 system for about $973. The monitor, operating system (Windows XP Home), keyboard, and mouse are included in that price. However, tax and shipping are not.

Background

RAID 0s work best with similar, if not identical, drives. You'll at least need to use drives of the same capacity, such as 80GB. In most situations, if you use drives of different sizes, you won't be able to access the larger drive's extra room. In other words, a 120GB drive paired with an 80GB unit in a RAID 0 will look like 160GB (two 80GB drives) to the PC.

We bought two 160GB Maxtor DiamondMax Plus 9 (model 6Y160M0) hard drives for our RAID at $105 each. These are 7,200rpm drives with 8MB cache buffers, which currently provide the best balance of performance, price, and capacity. These Maxtors also use the newish Serial ATA interface, which can

System Specs

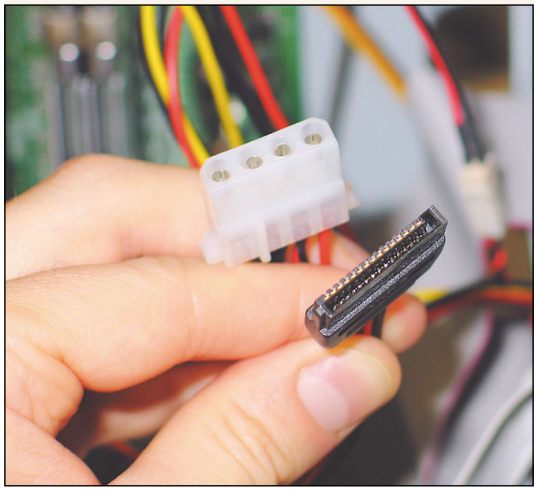
Here's the brag sheet for our low-buck racehorse:

- AMD Athlon 64 2800 1.8Ghz, 512K Cache, 754-pin
- Epox EP-8HDA3+ motherboard
- 256MB (2x128MB) MemoryPRO DDR400 SDRAM
- 320GB RAID 0 (2x160GB Maxtor 6Y160M0 hard drives), 7,200rpm, 8MB caches
- OptoRite 8X/4X/12X DVD±RW / 40X/24X/40X CD-RW
- Dual LAN: Gigabit, 10/100MBps
- Dual S/PDIF outputs; 5.1-channel audio
- Six SATA ports; external SATA bracket included

carry data at a slightly higher rate (150MBps) than the older ATA/EIDE/DMA interface (100MBps or 133MBps). Although both interfaces are more than fast enough for a single hard drive, two drives working together in a RAID 0 may require SATA's 150MBps bandwidth.

Watch Out

Serial ATA hard drives are meant to use a different type of power cable, which has an L-shaped connector longer than a SATA data cable's. However, many SATA drives come with both SATA and regular, 4-pin Molex power jacks (most PC power supplies have only the Molex kind). Attach one type of power cable or the other to the drive, but not both at once. ▲



Because a RAID 0 is a little riskier than a single drive—let alone one of the fault-tolerant varieties of RAID, such as 1, 5, or 1+0—we added a DVD burner for backup purposes. Besides storing up to 4.7GB on DVD+R/RW and DVD-R/RWs, the Optorite DD0405 also burns CD-Rs at 40X speed. Price cuts just before press time on put double-layer DVD±RW burners in the same cost bracket. DL drives can put up to 8.5GB on compatible discs.

Our main focus for this PC is the RAID itself, so we cut back on the graphics card and other components. However, the 64-bit AMD Athlon 64 2800+ won't squander the RAID's extra speed. The Epox EP-8HDA3+ motherboard gave us a lot for $99, including RAID 0 and 1 support on its six SATA ports.

The Build

Our new RaidMax 278WBP Mirage case had bays in spades. Unfortunately, its front panel's plastic mounting pins were broken, possibly in transit, so the fascia didn't attach properly to the steel case. However, it did have a bare-bones power supply and glowing blue sections that looked pretty trick. A large, Plexiglas window in the case's side panel supported an 80mm intake fan.

Epox gave us two SATA data cables and power adapters with our motherboard. This was enough for the two-drive RAID 0 we would build. Epox also included ribbon cables for our floppy and DVD drives, plus a joystick port and external SATA port on a bracket that fit in a rear PCI opening.

Better still, Epox also thoughtfully gave us SATA and SATA RAID drivers on diskettes to save us a step when we were building our system. With many motherboards, you need to supply SATA or SCSI drivers at a particular point during a clean installation of WinXP, and the Setup program is too dumb to look for them on CD. This means you'll need to copy the drivers to a floppy disk before installing Windows, which can be a problem if you don't have access to a working computer. Epox also gave us Trend Micro PC-cillin 2002 antivirus and Norton Personal Firewall 2003, although the photos on the CD and elsewhere showed Norton Ghost instead.

Getting physical. Making sure to touch bare metal occasionally to dispel static electricity, which will kill computer equipment, we held the motherboard in the RaidMax case temporarily to size things up. Using the board's metal-ringed mounting holes as guides, we installed metal standoffs in the case's motherboard panel. Standoffs are hexagonal fittings with male bolt threads on one end and female on the other; they come with most cases. Always install a standoff for each mounting hole on the mainboard, and don't leave any extra standoffs where there are no holes to avoid short circuits.

Next, we punched out the steel knockout on the back of the case where the motherboard's USB, Ethernet, and other ports would show. We took the motherboard's chromed port panel (called an I/O shield) from the Epox box and snapped it into the knockout hole. The I/O shield had a few knockouts of its own we had to push out to match the ports available on our motherboard's rear section.

Finally, we mounted the motherboard to the standoffs in the case using the screws RaidMax provided. One of the I/O shield's PS/2 holes had a grounding tab that we had to bend out of the way a little, but we made sure it would still touch the keyboard/mouse ports' metal housing.

Before we added any more sensitive parts, we decided to fasten a second case fan in front of the 3.5-inch hard drive bays. RaidMax provided perforations for four 80mm fans in the front of the case, but those didn't leave us a good place to mount a single fan in the center, where it would do the most good. Furthermore, there was a raised section right in the middle. We flattened this using a bolt, nut, and a few washers so it wouldn't interfere with the fan. We attached the fan inside the metal case using two small bolts and nuts and connected its 3-pin power cable to the CHASSIS FAN header on the lower right corner of the mainboard.

Epox not only fortified the EP-8HDA3+ with ports and features, it sent the board out the door with lots of cables and extras.

Now we could install the Athlon 64. To do this, we moved the 754-pin CPU

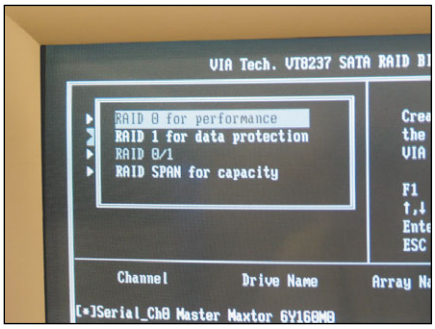
System Notes	
Benchmark Scores, RAID 0	
We ran PCMark04 (version 1.2.0, with Windows Media Player 9) and 3DMark03 (build 340, with DirectX 9.0) at default settings; HD Tach 3 with 32MB zones; IOmeter 2003.5.10's File Server test at one user, 16 outstanding I/Os; IOmeter's Web Server test at four users, 64 total outstanding I/Os. The ATI video card drivers were Catalyst 4.7.	
PCMark04 System	3360
CPU	3402
Memory	3440
Graphics	1275
Hard Drives	5624
3DMark03	1202
HD Tach 3	
Average read (MBps)	97.7
Maximum read (MBps)	120
Burst read (MBps)	178.3
Random access (ms)	13.9
IOmeter (inputs/outputs per second)	
File server	138.63
Web server	151.89

socket's lever out slightly and then up until it was perpendicular to the motherboard. We lined up the corner of the processor marked with a triangle with the corner of the socket missing a few holes and easily slipped the chip into place. Finally, we held the CPU in place, brought the lever back down, and locked the lever under the socket's retaining tab. This clamped the processor's legs in place.

We chose to use the heatsink, fan, and thermal compound putty that AMD packed with our retail-boxed Athlon 64. Overclockers may want to replace each of these with aftermarket alternatives from Vantec, Thermaltake, Arctic Silver, or others. Being careful not to disturb the thermal putty, we removed the heatsink's protective cover and tape. We settled the heatsink straight down onto the Athlon, using the motherboard's bracket as a guide. We clipped the two ends of the sink's metal retaining clip on the bracket's tabs and then turned the sink's plastic cam lever until its retaining arm clipped into place. Don't forget to connect the heatsink fan's cable to the CPU FAN power header on the motherboard.

Moving along, we snapped our two PC3200 DDR400 RAM modules into place, making sure the slots' white retaining clips were seated in both ends of each module. We routed the power supply's 20-pin and 4-pin cables to the proper connectors on the motherboard, which are easy to spot because nothing else will fit them.

We punched out the case's AGP-slot steel knockout to make way for our ill-fated Sapphire Radeon 9200 SE video card and then seated the card fully in the slot. One of the screws in the RaidMax case's grab bag held the graphics card's rear bracket down, and we flipped the AGP slot's white retention lever up to secure the bottom of the card.



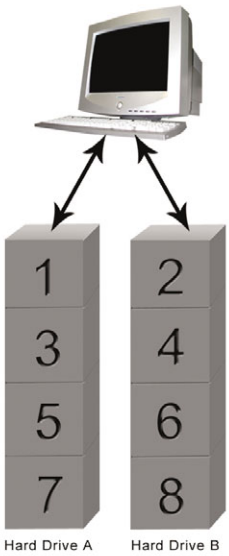
In the RAID setup utility for the VIA controller, we chose to create a RAID 0 for performance.

After we carefully connected the case's front switches, LEDs, and speaker to the proper pins on the motherboard, using the manual as a guide, we attached the mouse and keyboard. Next, we installed our floppy drive in an externally accessible drive bay. We poked out the corresponding plastic blind on the front panel and then had to move the drive forward a little to fit flush in the fascia. Finally, we attached a small power cable from the power supply to the drive and a data cable between the drive and the FDD header on the motherboard. Be sure to use the end connectors on the floppy cable, not the middle one, unless there's a second diskette drive. Also ensure that the end of the cable with a twist in its wires goes into the drive. The cable's red stripe goes toward Pin 1 on the drive, which should be marked.

Now we had enough parts to see if the PC would POST. It turned on and the fans ran, but there was no video signal. We tried other RAM modules and then another video card and discovered that our Sapphire 9200 SE was the problem. We substituted an ATI Radeon 9000 with 128MB, and the PC booted using an old WinMe system diskette we'd made.

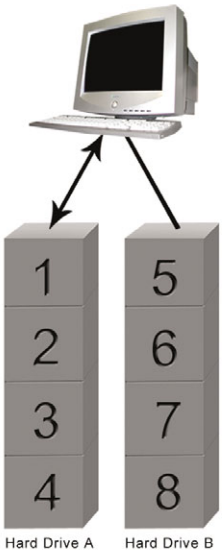
RAIDing party. To adjust the BIOS for the system we planned to build, we rebooted and pressed DEL to enter the BIOS Setup. Using the navigation keys shown on-screen, we set the PC to boot to a floppy, CD-ROM, and hard drive, in that order. This would let us use a boot diskette or bootable CD, when necessary. We

RAID 0



A RAID 0 writes partial data to two hard drives simultaneously, called striping. This dramatically increases read/write speed, but if either drive is flawed, the data on both drives could be lost. Data is not stored redundantly for fault tolerance.

Capacity: A + B



A PC moves data to/from one unRAIDed hard drive at a time. Data isn't backed up, but one drive's failure won't affect the other.

Capacity: A + B

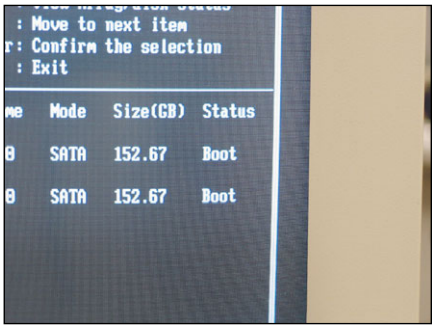
enabled support for our USB keyboard and mouse, changed the time and date, and set the AGP slot as the initial display path. The motherboard's SATA ports were already enabled and set to RAID in the BIOS, so we saved our changes and exited.

Shutting off the PC, we installed our two SATA hard drives and IDE DVD drive in the appropriate bays and connected power and data lines to each. We ran the hard drives' data cables to the SATA headers near the motherboard's VIA VT8237 southbridge chip, as this would have a 150MBps connection to the northbridge, RAM, and CPU. The Silicon Image SiI3114 secondary SATA controller would only be able to push 133MBps through the PCI bus, so it wasn't a good candidate for our speedy RAID 0.

We moved the DVD's rear jumper to make it the master device and attached its cable to the primary IDE channel (IDE1), a spot normally reserved for an IDE boot hard drive. However, we'd be booting from SATA drives, so this was OK. OptoRite had thrown in a black bezel with the DD0405, so off came the beige.

Before we could install Windows, we had to define our RAID 0 on the two Maxtor SATA drives. We rebooted and then pressed TAB to enter the VIA SATA RAID utility. There's a curve ball here: After we chose Create Array, we had to select an option misleadingly called Array Mode RAID 1 (Mirroring) to get to a menu of RAIDs 0, 1, 0/1 (0+1), and SPAN (JBOD; Just a Bunch Of Disks/Drives). We chose RAID 0 and selected our drives and then set the data block size to 32KB. This would trade a little speed for a more efficient use of hard drive space than a 64KB block size would give, although any performance difference would be small. We created the RAID, set it as the boot array, and then exited.

We inserted our WinXP CD-ROM and rebooted, entering the Windows Setup utility. There's a trick to installing WinXP to a SATA drive: You have to have quick reflexes. Early on, Setup briefly asked us to press F6 to install any third-party SCSI or RAID drivers. We did, pressed *S* when prompted, and inserted Epox's VIA SATA RAID diskette. You may have to make your own driver diskette on a working PC if one didn't come with your motherboard; follow the motherboard manufacturer's instructions. After we chose the driver for WinXP, Windows installed normally on our new RAID 0.



In the VIA RAID utility, we set our new RAID 0 array as the boot device. We also had to change the BIOS to allow booting from a SATA or SCSI drive.

Testing

For testing in this section of the magazine, we used a couple of hard drive benchmarks in addition to the usual PCMark04 and 3DMark03 from Futuremark. HD Tach 3 offers a glimpse at a drive's or RAID's read and access rates, while IOmeter 2003.5.10 lets us run custom tests designed to simulate usage as a file server and Web server with multiple users. The Benchmark Scores chart in this article lists our results and benchmarking notes.

Clearly, RAID 0 offers top speed on the cheap, like dropping a Chevy smallblock crate engine into your decrepit little Monza. Of course, there's little margin for safety in either case.

Final Remarks

Altogether, our RAID 0 160GB drives ended up with 320GB of blazingly fast storage space. Despite its low-end 3D card, this PC felt really spry and responsive during file transfers. Having an Athlon 64 can't hurt.

Intrigued? Keep reading. The next few articles will teach you how to build more fault-tolerant types of RAIDs for PCs around the $1,000 mark. RS

by Marty Sems

RAID 0

Minimum number of drives	Total capacity	Benefits	Drawbacks
Two	100% of both drives	Terrific speed	Double the risk of data loss

Parts List

We used Pricegrabber and Pricewatch to find rock-bottom prices from online vendors. However, we recommend spending a few bucks more at reliable dealers, such as Newegg and ZipZoomFly. Here's how our RAID 0 monster became a reality for less than a thousand bucks.

Component	Model	Price
Case	RaidMax 278WBP Mirage ATX Mid Tower	$38
Motherboard	Epox EP-8HDA3+ *	$99
Processor	AMD Athlon 64 2800 1.8GHz 512K Cache	$187
Memory	256MB MemoryPRO (2x128MB) DDR400 PC3200	$52
Hard Drives	2x160GB Maxtor 6Y160M0 SATA 7200rpm 8MB cache ($105 each)	$210
Video Card	ATI Radeon 9200 AGP 128MB TV-Out *	$69
Optical Drive	Optorite DD0405 8X/4X/12X DVD±RW Writer	$70
Monitor	Samsung SyncMaster 753DF (17 inch, 1280 x 1024, 0.20mm)	$119
Floppy Drive	Sony MPF920ZCU1 3.5in 2HD Floppy Drive Internal	$4.88
Power Supply	RaidMax KY-450ATX 350W (Included with Case)	
Mouse	Logitech Optical Wheel 3-Button Mouse	$8.59
Keyboard	Belkin ErgoBoard USB / PS/2	$16
Operating System	Windows XP Home Full OEM Version	$90
Miscellaneous	Compuman 80mm Case Fan; Misc. Bolts, Nuts *	$10
Total		**$973.47**

* Equipment previously purchased.

RAID 1 Under $1,000

Slow & Steady Wins The Race?

Build #23 Skill Level: 1 **2** 3 4 5 ***Apprentice***

Somewhere between creating that ultra-important spreadsheet and doing your next scheduled backup, your PC had a hard drive failure. Bye-bye spreadsheet, and hello reinstallation of everything on your computer.

If you can't afford any downtime with your personal or business PC, not even the hour or so it takes to do a full disaster recovery from backup media, this article is for you. There's no simpler type of backup than a second hard drive that's automatically maintained as an identical twin of your boot drive.

Goal

Like a RAID 0, described in the previous article, a RAID 1 writes data to and reads it from multiple hard drives at once. The difference is that whereas RAID 0 writes part of a file on one drive and part on another, a RAID 1 writes a complete copy of every file to both drives. In other words, if either hard drive has a problem, the other drive is ready to step into the breach and be the sole boot device. When you replace the faulty drive, the RAID 1 can rebuild itself by mirroring the boot drive to the new replacement (also called synchronization).

The obvious downside to a RAID 1 is that it's inefficient: It will only let you store half as much data as if you simply installed both drives in your PC without RAIDing them. A RAID 1 will also be no faster than a single drive.

Fortunately, like a RAID 0, a RAID 1 is cheap to implement. Virtually all motherboards that can RAID hard drives will support array types 0 and 1. Furthermore, both RAID 0 and 1 only require a minimum of two drives. Depending on the RAID controller on the motherboard or adapter card, you might be able to add a third hard drive as a spare. Certain controllers will automatically copy the remaining good drive to a spare if one RAID 1 drive fails.

As with a RAID 0, most controllers work best with hard drives of the same make, model, and capacity. This minimizes mismatches in read/write timing between the drives, as well as preventing the loss of extra storage space in a drive that's bigger than its partner in the RAID.

In this article, we'll tell you how we assembled a decent RAID 1 PC for less than $1,000, plus tax and shipping. This is just a template, of course, so feel free to upgrade as you like.

Background

Because of the capacity drop in a RAID 1, the first priority is to buy hard drives big enough to give you enough total storage space. We chose 160GB Maxtor DiamondMax Plus 9 SATA drives (model 6Y160M0; $105 each) for a 160GB final capacity, half of the 320GB they would provide as unassociated or RAID 0 drives.

As for the rest of the PC, we tried to balance speed, features, and modest cost. The $70 8X/4X/12X DVD burner can back up precious business data to either DVD-R/RWs or DVD+R/RWs, 4.7GB at a time. An impressive Athlon 64 will crunch that data in a hurry, while the Radeon 9200 SE

System Specs

Here's how our reliable, fault-tolerant data warehouse sits.

AMD Athlon 64 2800 1.8GHz, 512K Cache, 754-pin

Epox EP-8HDA3+ motherboard

256MB (2x128MB) MemoryPRO DDR400 SDRAM

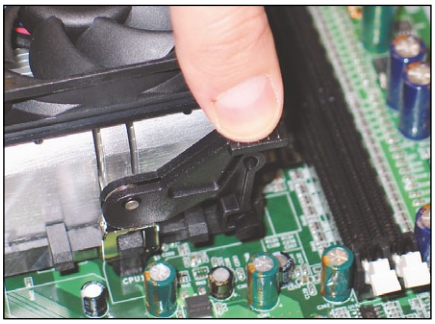
320GB RAID 0 (2x160GB Maxtor 6Y160M0 hard drives), 7,200rpm, 8MB caches

OptoRite 8X/4X/12X DVD±RW/ 40X/24X/40X CD-RW

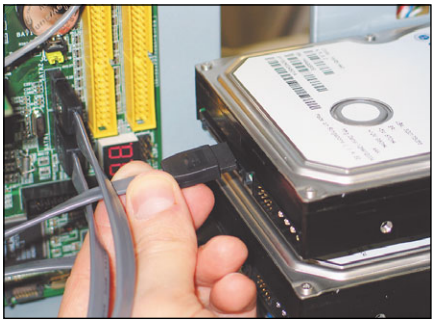
Dual LAN: Gigabit, 10/100MBps

Dual S/PDIF outputs; 5.1-channel audio

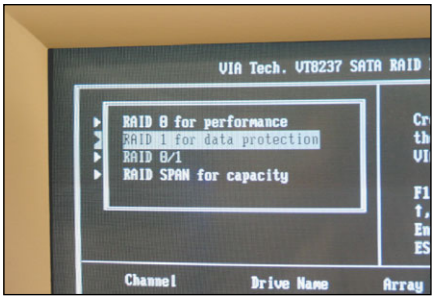
Six SATA ports; external SATA bracket included



Heatsinks for Athlon 64s have a cam lever to keep them pressed against the processor. After you attach the sink's metal clips to the socket bracket, turn the cam lever until it locks.



Slender SATA data cables let air flow unimpeded through your PC. That's especially important for cooling multiple hard drives.



We pressed TAB after bootup to reach the VIA RAID utility. Here, we choose to build a RAID 1 with our two hard drives.

video card will handle any business or light gaming task. We do recommend doubling the RAM to 512MB at least, though, and going with a more established brand such as Corsair, Micron/Crucial, or Kingston. We stuck with 256MB for dumb budgetary reasons.

Honestly, it will be a much better time to build a PC in a few months than it is as of this writing. There are several new technologies that are just emerging, none of which we could include by deadline. However, they'll make your PC more upgradeable in the future. Consider trading up to the following: a 939-pin AMD Athlon 64; a PCI Express video card; DDR2 memory; and, of course, a motherboard that can support all of these.

The Build

RaidMax supplied two USB ports in the 278WBP's fascia under a concealment panel, plus knockout holes for us to add our own FireWire, headphone, and microphone jacks. Unfortunately, that concealment panel felt pretty flimsy. The company also used fairly thin steel in the rest of the case to keep its cost low, but that also makes the finished system light enough to move around easily. Our case did have a few burred edges, but none were in areas we would grab during a typical assembly. Furthermore, none of the edges was sharp enough to cut an intern's fingers, and this intern was particularly thin-skinned.

Moving aside the thorough Epox users manual, case badge sticker, and fold-up desk calendar, we removed our EP-8HDA3+ motherboard from its box and antistatic plastic bag. Its dual LAN ports, one of which supports Gigabit Ethernet, should help our new PC fit right into a business environment. After hours, its dual S/PDIF audio outputs will complement the DVD drive and Radeon 3D card for entertainment while you unwind.

It's a standoff. We used the Epox mainboard as a guide to help us install brass-colored standoffs in our case. These male-female threaded spacers, included with the RaidMax and most other brands of cases, keep the motherboard firmly mounted about a quarter of an inch from the inner panel of the case. Never skip these. If you bolted the mainboard directly to the case without standoffs in between, the soldered points on the underside of the board would almost certainly short out. This would also be a hazard if you carelessly installed a standoff where the board had no mounting hole. When properly installed, standoffs also facilitate some ventilation behind the board. The thin space between the board and case panel acts as a chimney through which warm air rises and draws cooler air from below.

We removed a knockout panel in the rear of the case to let us install the Epox board's I/O shield, a chromed rectangle with custom apertures for the board's USB, audio, and other ports. After we double-checked our standoff positions and tightened the standoffs with a small wrench, we fastened the motherboard to them. We used bolts from the grab-bag of screws and other hardware that RaidMax included with our case. Next, we connected the 20-pin and 4-pin power cable harnesses from the case's power supply to their sockets on the upper left of the motherboard. Some boards and CPUs don't require the 4-pin supplemental power cable, but ours did.

Next, we connected the front panel's switches, ports, and lights to the pins in the mainboard's lower-right corner. These are tricky waters, so take a good treasure map: the motherboard's manual. It's very easy to slide the tiny cable connectors onto the wrong pins or slip them on backward, so double-check your work. White or black wires usually indicate negative polarity (-), and colored wires are generally positive (+).

Processor process. To seat the Athlon 64 CPU in its socket, first unlatch the socket's locking lever. Push the metal or plastic lever a little to the side and then pull the

System Notes

Benchmark Scores, RAID 1

We ran PCMark04 (version 1.2.0, with Windows Media Player 9) and 3DMark03 (build 340, with DirectX 9.0b) at default settings; HD Tach 3 with 32MB zones in the first 10GB partition; IOmeter 2003.5.10's File Server test at 1 user, 16 outstanding I/Os in a second 10GB partition; IOmeter's Web Server test at 4 users, 64 total outstanding I/Os. The ATI video card drivers were Catalyst 4.7.

	RAID 1	One 160GB Drive
PCMark04	3388	3373
CPU	3410	3405
Memory	3444	3444
Graphics	1274	1275
Hard Drives	871	4897
3DMark03	1200	1201
HD Tach 3		
Average read (MBps)	48.8	48.4
Maximum read (MBps)	60	60
Burst read (MBps)	115.6	116.3
Random access (ms)	14.2	14.2
IOmeter (inputs/outputs per second)		
File server	125.06	124.14
Web server	154.91	153.96

lever upward until it's pointing straight away from the socket. Find the triangular mark on one corner of the Athlon 64, which designates a corner without as many pins as the others. This corresponds to a similar corner of the socket. The processor should drop into the socket holes easily when it's oriented correctly. After it does, hold the chip down with light finger pressure while you bring the locking lever back down. Once the lever snaps alongside the socket, internal contacts will clamp each of the CPU's tiny legs, keeping the processor from falling out.

We received an AMD-approved heatsink and fan with our CPU's retail package. Note that chips sold as OEM instead of retail or boxed won't come with either of these necessities. Being careful not to touch the square of thermal putty AMD applied to our heatsink, we removed the sink's plastic cover. Turning the heatsink so that its metal latches corresponded to the socket's tabs, and so that we would be able to get a hand on the sink's large plastic cam lever later, we set the sink straight down on the CPU. We made sure both metal latches hooked onto the socket and then turned the cam lever until it locked in place. Finally, we slipped the 3-wire fan cable connector onto the motherboard header (group of pins) marked CPU FAN. If you forget this step, a motherboard with thermal protection will shut off your PC soon after you start it. A board with no such protection will let your expensive CPU fry.

RAM is easy to install. It only goes in one way and snaps straight down into place with a little firm finger pressure on each end. We flicked the small levers on the ends of each RAM slot into the notches in our DDR modules. The same went for the AGP slot's lever, which we toggled into place after inserting the Radeon 9200 video card, a replacement for a defective $43 Radeon 9200 SE we bought. If your case is new, you might have to press a cutout out of the case's rear to allow the AGP card's bracket external access. We screwed the top of the bracket into place and then connected our Samsung monitor's VGA video cable to the Radeon card.

With one more glance at everything we'd assembled, we added the AC power cord and turned on the half-finished PC. It worked fine until the inevitable halt when it found no boot disk, CD, or hard drive. All this was as it should have been. We needed to check a few things in the BIOS Setup before we continued, so we rebooted and pressed DELETE at the brief prompt. We set the boot device order to floppy, CD-ROM, and then a SATA or SCSI hard drive. We set the clock, turned on support for our USB keyboard and mouse, and set the AGP slot as the graphics bus. The BIOS already listed RAID for our SATA ports' function, so we saved our changes and exited the Setup program.

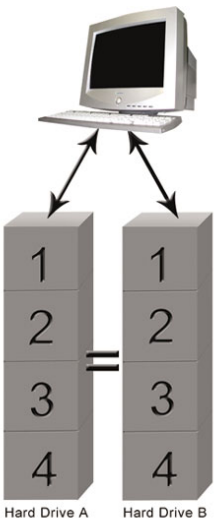
Windows Setup
You have chosen to configure a SCSI adapter for use with Windows, using a device support disk provided by an adapter mmanufacturer.
Delect the SCSI Adapter you want from the following list, or press ESC to return to the previous screen.
VIA Serial ATA RAID Controller(Windows XP)
VIA Serial ATA RAID Controller(Windows 2000)
VIA Serial ATA RAID Controller(Windows NT4)

If you press F6 at the right time near the beginning of Windows XP Setup, you'll be able to select the SATA RAID driver WinXP needs from a floppy diskette.

Going driving. It was time to install our drives. We bolted our floppy drive and DVD drive into open bays, removing plastic knockout plates from the front panel to let us slip media into the drives later. We attached a 4-pin power cable to the DVD and a smaller power lead to the floppy. Next, we took an EIDE and a floppy data cable from the Epox motherboard's box. Using only the connectors on the ends of the cables, we linked both drives to the proper headers on the motherboard. We made sure that the cables' red stripes corresponded to Pin 1 on each drive, and that the floppy cable's twist was nearest the drive.

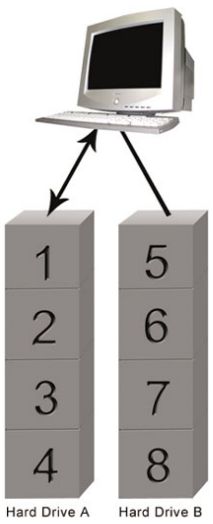
We installed our two Maxtor hard drives in a similar way in the lower 3.5-inch drive bay. Epox had given us two SATA data cables with our motherboard, which we installed between the drives and the headers nearest the VIA southbridge chip. We used regular 4-pin Molex leads from the power supply. If your motherboard or power supply comes with adapters to SATA-style power connectors, you

RAID 1



A RAID 1 writes identical data to two hard drives simultaneously, called mirroring. If one drive fails, all data will still be preserved on the other. Speed is about the same as with a single drive, but there's a major loss of total storage space.

Capacity:
Half of A + B



A PC moves data to/from one unRAIDed hard drive at a time. Data isn't backed up, but the computer can use the total capacity of both drives.

Capacity:
A + B

can use them in place of—not in addition to—the Molex style.

In order to designate our hard drives as a RAID before installing Windows, we entered the VIA SATA RAID utility. To do this, we pressed TAB during bootup. We selected Create Array and then Array Mode RAID 1 (Mirroring) and RAID 1 For Data Protection. Next we chose Select Disk Drives (pressing ENTER to highlight both Maxtor 160GB drives) and then Start Create Process. The utility asked us if we wanted to copy one drive's contents to the other. We typed *N* for no, as there wasn't anything on either drive yet. After VIA warned us that any data on our drives would be "destoried," whatever that is, we went ahead with the array creation. Back in the main menu, we chose Select Boot Array to designate our new RAID 1 as the boot device.

We inserted our Windows XP CD and then exited the VIA utility. Our system rebooted. Note that WinXP Setup won't recognize a SATA drive or RAID without some help from the user, so you have to carefully watch the first moments of the program. When Setup asked us momentarily to press F6 to install any third-party SCSI or RAID drivers, we did. Pressing *S* when prompted, we inserted the VIA SATA RAID driver diskette that came with our Epox mainboard. (Follow the board manufacturer's directions to make a driver diskette if you didn't receive one with your motherboard.)

We directed Windows Setup to create partitions on our new RAID, starting with a 10GB C: partition for the OS. Everything went smoothly, and when the desktop finally appeared, we verified in My Computer that we had 160GB of total storage. We installed the latest drivers for our hardware, including the VIA 4-in-1 for the motherboard chipset, and Windows updates.

After some thought, we decided to flip the fan in the middle of the side panel window. It was a fairly strong air mover, set up to push exhaust air out of the case. We already had a moderate exhaust fan in the power supply, but for intake, we had only the weak fan we'd placed in front of the hard drives. We've had good luck with slightly more air intake pressure than exhaust, so we unscrewed the side panel fan and reattached it facing inward.

Testing

Using the same benchmarks as we did with our RAID 0 system, we found that there's definitely a price to pay for RAID 1's brand of safety. Its read rates were exactly half those of the RAID 0, all components being equal. Furthermore, the RAID 0 outpaced the RAID 1 by 15% in PCMark04's hard drive test and 11% in IOMeter's file server benchmark.

That said, our RAID 1 was no slower than a single drive in our tests. If you added a new drive to an existing PC in a RAID 1, you wouldn't notice any difference in speed or capacity. However, you would have an exceptional no-brainer of a backup system.

Final Remarks

Even if you're satisfied with the data redundancy of your new RAID 1, remember that it's still very important to back up that data to other media. A strong power surge could zap both drives in your PC at the same time, or a thief could simply walk out with the whole system. Also, you should store those backup tapes or discs offsite so a fire or other disaster couldn't destroy every copy.

For a look at other types of redundant RAID systems in the same price bracket, only with better drive speed and efficiency, keep reading. Next up is RAID 0+1. RS

by Marty Sems

Time-saver

Our only change to the RaidMax case was to add an 80mm Compuman case fan in front of the 3.5-inch drive bays. If the case holes available are too small for fan screws, which are typically fat with few threads per inch, drill the holes bigger or use skinnier bolts with nuts. ▲

RAID 1

Minimum Number Of Drives	Total Capacity	Benefits	Drawbacks
2	50% of both drives	1:1 data redundancy, easy to rebuild after a drive failure	Cuts total storage space in half; speed of a single drive

Parts List

It made sense to build this two-drive RAID 1 system with the same components as our RAID 0 PC in the previous article, as both types of RAID are supported by the motherboard and have a two-drive minimum. The RAID 1 won't be as fast as the RAID 0—or any faster than a single hard drive—but it will be a lot more trustworthy with our data.

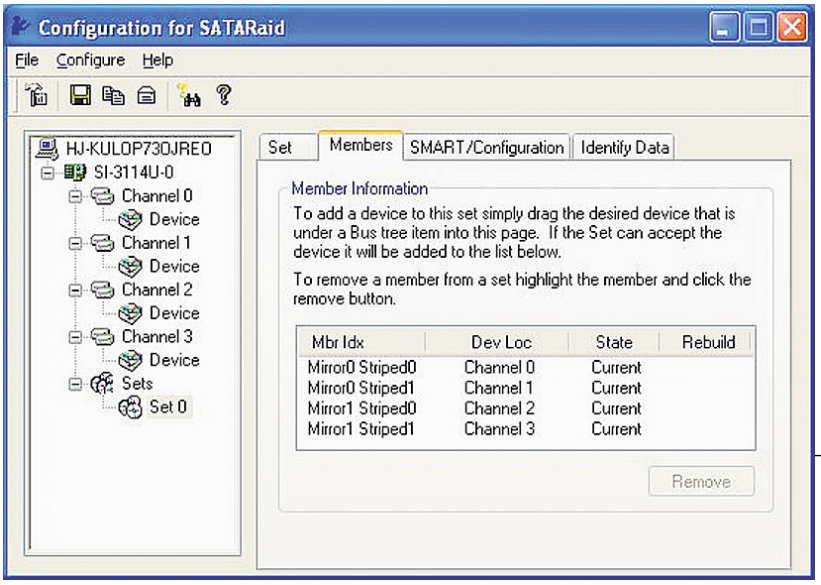
Component	Model	Price
Case	RaidMax 278WBP Mirage ATX Mid Tower	$38
Motherboard	EPoX EP-8HDA3+ *	$99
Processor	AMD Athlon 64 2800 1.8GHz 512K Cache	$187
Memory	256MB MemoryPRO (2x128MB) DDR400 PC3200	$52
Hard Drives	2x160GB Maxtor 6Y160M0 SATA 7,200rpm 8MB cache ($105 each)	$210
Video Card	ATI Radeon 9200 AGP 128MB TV-Out *	$69
Optical Drive	Optorite DD0405 8X/4X/12X DVD±RW Writer	$70
Monitor	Samsung SyncMaster 753DF (17-inch, 1280 x 1024, 0.20mm)	$119
Floppy Drive	Sony MPF920ZCU1 3.5-inch 2HD Floppy Drive Internal	$4.88
Power Supply	RaidMax KY-450ATX 350W (included with case)	
Mouse	Logitech optical wheel three-button mouse	$8.59
Keyboard	Belkin ErgoBoard USB/PS/2	$16
Operating System	Windows XP Home full OEM version	$90
Miscellaneous	Compuman 80-mm case fan; misc. bolts, nuts *	$10
Total		**$973.47**

* Equipment previously purchased.

RAID 0+1 Under ~~$1,000~~ $1,100

Speed Of RAID 0, Fault Tolerance Of RAID 1

Build #24 Skill Level: 1 **2** 3 4 5 ***Apprentice***



Because of a typo in Silicon Image's RAID creation utility, we had to install Windows and the SATARaid software before we could confirm that we'd really made a RAID 0+1.

You're sold. You want a RAID (redundant array of inexpensive disks/drives). Maybe you've witnessed the phenomenal speed of a RAID 0, or perhaps you want the safety net of immediate data backup that a RAID 1 offers. In any case, you're ready to take the plunge. ("RAID 0 Under $1,000" and "RAID 1 Under $1,000" have more details on RAIDs 0 and 1.)

But hang on. What about the risks of a naked RAID 0? And isn't a RAID 1 no faster than a single hard drive? Moreover, you'd rather spend your money on bigger hard drives than on an add-in RAID controller card, so you want a RAID with support built into a motherboard. The answer might be RAID 0+1.

Goal

A RAID 0+1 starts with a pair of striped hard drives, meaning that the PC writes part of each file to both drives for nearly double the read/write speed. But that's a little risky because if either drive fails, you might not be able to access any of the data. So the RAID mirrors the data, or copies it, to another RAID 0 drive pair so that there will be an automatic backup at all times. In effect, RAID 0+1 is a RAID 1 made up of two RAID 0 arrays. It combines the speed of RAID 0 with the data redundancy of RAID 1.

RAID 0+1

Minimum Number Of Drives	Total Capacity	Benefits	Drawbacks
Four	50% of all drives	RAID 0's speed, RAID 1's protection	Expensive; low usable capacity

You need at least four hard drives to make a RAID 0+1, which is why few people do it. (*NOTE: Intel's Matrix Storage Technology, built into its 915G, 915P Express, and 925X Express chipsets, provides RAID 0+1's primary benefits in a different manner. Using only two drives, MST divides part of the array into a RAID 0 for speedy app loading and the remaining part into a RAID 1 for personal data safety.*) RAID 0+1 is out of most enthusiasts' price range, yet it's not efficient, scalable, or fault-tolerant enough for critical business uses. Out of those four drives, RAID 0+1 loses half the storage space to backup data. Furthermore, it also necessitates a computer case that can hold four drives and keep them cool, not to mention a power supply with enough oomph to run them all.

Don't confuse RAID 0+1 with RAID 10, by the way. A RAID 10 has a striped pair of drives like RAID 0+1, but it backs these up to a pair of mirrored hard drives for a total of three copies of all data. RAID 10 is very reliable, but it loses a lot of capacity keeping all that backup data. For most desktop users, it makes more sense to use more of their drives' space in a different type of RAID and make regular backups to DVD or tape.

Here's how we almost succeeded in making a RAID 0+1 PC for less than $1,000. A few component shuffles from out-of-stock or defective parts put us over that mark, but we've included tips on bringing the price down.

Background

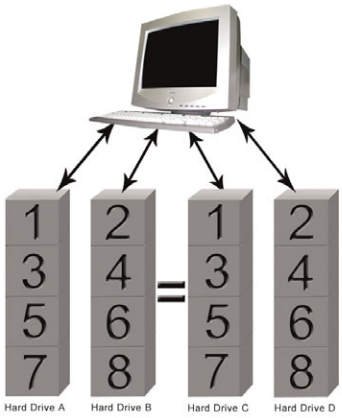
Four 160GB Maxtor DiamondMax Plus 9 SATA hard drives seemed perfect for this ambitious RAID 0+1 system. Fortified with 7,200rpm spindle speeds and ample 8MB caches (found in model 6Y160M0), these zippy hard drives cost us $105 each.

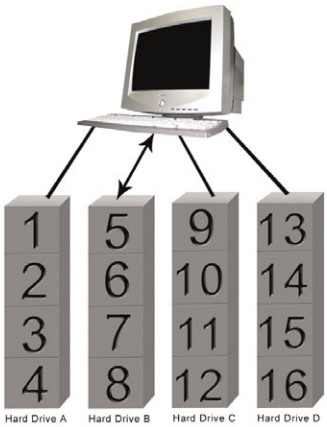
The $420 hard drive bill forced us to look for less expensive hardware with great features. We bought an Athlon XP 2000+

RAID 0+1

A RAID 0+1 stripes partial data to a pair of hard drives for speed, like a RAID 0. It also mirrors that same data to another striped RAID 0 for redundancy, like a RAID 1.

Capacity: Half of A + B + C + D





A PC moves data to/from one unRAIDed hard drive at a time. Data isn't backed up, but one drive's failure won't affect the others and no capacity is lost.

Capacity: A + B + C + D

(a 2500+ cost just $22 more). We also bought a motherboard that ostensibly supported RAID 0+1, although it was a mystery just what type of RAID we'd created until we installed Windows and a RAID monitoring utility. The DFI NFII Ultra Infinity motherboard's box and docs all claimed RAID 0+1 support from its Silicon Image 3114 controller chip, but the preboot SiI RAID utility said that it offered RAID 10 instead.

The final necessity was an Antec True430W power supply, which would offer enough amperage on its 12V rail (26A) to be able to start the computer with all those hard drives. The remainder of our PC parts reflects the bare minimum hardware available at low prices.

Two changes could make this system ring up for less than $1,000, which was our original intention. One is to use 120GB drives, which would have saved us about $52 as of this writing. The other is to use a lighter graphics card, such as the $43 Radeon 9200 SE we originally purchased but had to return. Together, these two modifications will net you a $982 RAID 0+1 PC, not including tax or shipping.

The Build

Our RaidMax case came with a 350W power supply with 10A on the 12V rail, which we knew wouldn't be strong enough to fire up all the hardware we'd bought. We unscrewed it and pulled it from the case. However, we didn't install the new Antec power supply just yet, as we'd learned from "Lowest-Priced Terabyte System" (see page 108) that we'd need the room when we installed the CPU's heatsink.

Next, we placed the case on its side. We installed standoffs in the case's motherboard panel using our DFI NFII's silver-lined mounting holes as our guide. After fitting the included chromed I/O shield, or port plate, to the hole in the back of the case, we screwed the mainboard into place in the RaidMax case.

We lifted the CPU socket lever to 90 degrees, dropped the Athlon XP 2000+ into place (it will only fit facing one direction), and snapped the lever back down parallel to the socket. Next, we unwrapped the retail CPU's heatsink/fan combo, making sure not to smudge its preapplied thermal putty. The bottom of the heatsink had a recess meant to face the high part of the CPU socket, so like the processor, the heatsink could only face one way. Holding the sink at a slight angle, we snapped one end of its metal clip over the socket's tabs. Next, we set the sink on the Athlon chip and cautiously used a well-fitting, flat screwdriver to press the other end of the metal clip down over that side's tabs, locking the sink down. Finally, we connected the fan cable to the CPU FAN header on the motherboard.

Power to the PC. Now we could install the Antec power supply. This particular Antec came with its main harness neatly sleeved in black mesh, plus a large intake fan that fortuitously ended up right above our CPU. We snapped its 20-pin and 4-pin power leads into the motherboard, turning the connectors until they fit. The Antec also came with a couple of SATA power connectors. A few SATA hard drives require this type of power coupling; more often, they accept either SATA or typical 4-pin Molex connectors. If this describes your hard drive, use one or the other power lead type (never both).

Our matching DIMMs of DDR400 SDRAM from MemoryPRO went in next. The RAM could only go in one way, so we pushed them into the DIMM slots with moderate finger pressure on their top edges. We made sure the white end retainers pivoted up to fit in each stick's notches.

Next, we installed our Radeon 9200 graphics card, screwing its bracket down and flipping up the retention lever on its AGP slot. We attached our monitor's video cable to the rear of the Radeon card and then followed the DFI users manual to connect the front-panel LEDs and switches to the mainboard. These can be tricky, so use a flashlight, mirror, or magnifying glass if you need to.

Finally, we ran power cords to the PC and monitor and turned the system on. We knew it wouldn't get far without an OS or boot diskette, but at least we found out that the hardware worked. We pressed DEL to enter its BIOS Setup program, which you should always check when you're using a new motherboard. We set the clock and date; rearranged the boot devices to Floppy, CD-ROM, and SCSI (BIOSes often consider SATA drives as

System Specs

The fast storage system helps to compensate for the older processor, making this PC feel quick during everyday tasks.

AMD Athlon XP 2000+ 1.67GHz, 266MHz frontside bus, 128KB L2 cache, 462-pin (Socket A)

DFI NFII Ultra Infinity motherboard

256MB (2x128MB) MemoryPRO DDR400 SDRAM, dual-channel

320GB usable storage (4x160GB Maxtor DiamondMax Plus 9 SATA hard drives; 7,200rpm; 8MB caches)

AOpen 52X/32X/52X Chameleon CD-RW

10/100MBps LAN

SPDIF output and input; 5.1-channel Realtek ALC650 audio

Four SATA ports

FireWire 400MBps

16.5h x 8w x 19d inches; 29 lbs.

SCSI devices for system configuration purposes), in that order; and set the Init Display First field to AGP instead of PCI. We saved our changes, exited, and shut down the PC.

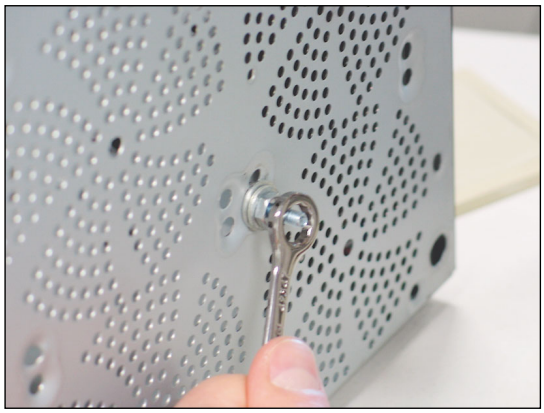
Drive time. We stood the computer on its feet again. Then, from top to bottom, we installed our drives in the front bays of the case. We had to pop out two plastic panels in the case's fascia for our CD-RW drive and floppy drive and then secured the drives in their bays with four screws each. If you use fewer screws, especially on optical and hard drives, you run the risk of letting uneven vibrations affect the drives' error rates, transfer speeds, and possibly lifespan.

Moving down to our four hard drives, we handled them gently as we slipped them into the lower 3.5-inch bays and bolted them in place. We had already installed an 80mm case fan in front of the drive cage, first flattening a raised section in the middle of the panel with a bolt, nut, and some washers (see "RAID 0 Under $1,000" on page 92 for more details). With so many hard drives and a hot motherboard chipset like our NFII Ultra Infinity's Nforce2, we knew we had to add at least one more fan to the RaidMax case's side fan (which we flipped to blow inward instead of outward).

Once our drives were snug, we connected data and power cables to them. The CD-RW used an ATA/133 cable included with the mainboard to attach to an IDE header on the board, as well as a smaller audio cable to reach the board's distant CD audio input header. The floppy drive took a smaller power connector from our Antec supply. Its data cable, also supplied by DFI, had a twist that went toward the drive and a red stripe that faced Pin 1 on the drive, which is marked with a triangle. Use the end connectors of a floppy drive cable; the middle one is for a second diskette drive (B:).

Finally, we added either SATA or 4-pin Molex power leads to each hard drive (never both). Being careful not to break any fragile SATA ports, we then ran SATA data cables from the drives to the four ports on the DFI motherboard. We were now ready to create our RAID, install Windows, and test the monster we'd just built.

RAID creation. We started the PC. At the prompt a few seconds later, we pressed CTRL-S to start Silicon Image's RAID utility. We chose Create RAID Set and then RAID 10. (This eventually proved to be a typo for RAID 0+1, although we didn't find that out until later.) Note that if your particular motherboard doesn't recognize your USB keyboard or mouse in the utilities that load before Windows, such as this one, fit the device with a USB-PS/2 adapter and restart the system. You might also have to press NUM LOCK before



Here's how we flattened an area in front of our hard drive bays to accept an 80mm case fan. We also had good results prying on the bolt with the box end of the wrench.

Parts List

Price changes and component swaps put us over our $1,000 target. However, a Radeon 9200 SE video card and 120GB drives would have priced this PC at around $982.

Component	Model	Price
Case	RaidMax 278WBP Mirage ATX Mid Tower	$38
Motherboard	DFI NFII Ultra Infinity	$86
Processor	Athlon XP 2000+ 266MHz retail	$57
Memory	256MB MemoryPRO (2x128MB) DDR400 PC3200	$52
Hard Drives	4x 160GB Maxtor 6Y160M0 SATA 7,200rpm 8MB cache	$420
Video Card	ATI Radeon 9200 AGP 128MB TV-Out *	$69
Optical Drive	AOpen 52X/32X/52X Chameleon CD-RW	$26
Monitor	Samsung SyncMaster 753DF (17-inch, 1,280 x 1,024, .20mm)	$119
Floppy Drive	Sony MPF920ZCU1 3.5-inch 2HD Floppy Drive Internal	$4.88
Power Supply	Antec True430 430W	$59
Mouse	Logitech Optical Wheel 3-Button Mouse	$8.59
Keyboard	Belkin ErgoBoard USB; PS/2	$16
Operating System	Windows XP Home full OEM version	$90
Miscellaneous	Compuman 80mm case fan; two extra SATA cables; misc. bolts/nuts*	$15
Total		**$1,060.47**

* Equipment previously purchased.

you can type numerals on the right-hand keypad.

At this point, instead of choosing Auto Configuration, we selected Manual Configuration to get a better understanding of the process. We decided on a 16KB chunk size. Chunk is another term for allocation unit or cluster, which defines the smallest unit of storage the hard drives will use to store data. A 16KB size would make the drive speedier than would 4KB or 8KB chunks, yet less wasteful of storage space than would 64KB or 128KB clusters. As an example of that waste, if you saved a 5KB file on a drive with 128KB clusters, it would still take 128KB of space to save it, wasting 123KB.

Next, we pressed ENTER to select the first, second, third, and fourth drives of the RAID set. We simply chose our drives in the order they were listed. None of our hard drives had Windows or any other data on them yet, so we selected Create Without Data Copy. Choose the Create With Data Copy option if you're converting an existing system to a RAID 0+1 and you don't want to reinstall your OS and apps. We continued and found ourselves back at the main menu, the proud owners of . . . an SiI RAID 0+1 array.

Still with no way of knowing if we actually had a RAID 10 or 0+1 on our hands, we slipped the Windows XP CD into the drive and pressed CTRL-E to exit the RAID utility. The system rebooted into Windows Setup. A few seconds later, we had to press F6 to install a third-party SCSI or RAID driver (if you miss your chance, reboot and try again). When Setup asked us, we inserted DFI's SATA RAID driver diskette and directed Setup to the driver for WinXP.

Later, when Setup showed us the space available on our RAID, it was 312GB, or roughly half of the 640GB we would have had without RAIDing our four 160GB drives. This supported the RAID 0+1 theory, we thought. We set up two 10GB partitions for Windows and our apps and then a third with 292GB for our data. Next, we installed WinXP on the first partition, choosing the NTFS file system. We had to eject the RAID driver diskette as WinXP Setup restarted the computer, and we also had to tell Setup twice to use those drivers without Microsoft certification.

System Notes

We ran PCMark04 (version 1.2.0, with Windows Media Player 9) and 3DMark03 (build 340, with DirectX 9.0b) at default settings; HD Tach 3 with 32MB zones over the entire 320GB array; IOmeter 2003.5.10's File Server test at 1 user, 16 outstanding I/Os; IOmeter's Web Server test at 4 users, 64 total outstanding I/Os; both run on the second 10GB partition of the RAID. The ATI video card drivers were Catalyst 4.7. For comparison, we disconnected two drives and reran all tests with the resulting RAID 0.

	RAID 0+1	RAID 0
PCMark04		
System	2769	2779
CPU	2798	2801
Memory	1936	1941
Graphics	1274	1276
Hard Drives	5233	5608
3DMark03	1154	1152
HD Tach 3		
Average read (MBps)	95	95.2
Maximum read (MBps)	111	110
Burst read (MBps)	114.2	114.5
Random access (ms)	14.6	14.1
IOmeter (inputs/outputs per second)		
File server	186.17	191.89
Web server	234.03	234

The plot thickens. Once we made it through typing in the product key and selecting a few network and clock settings, we reached WinXP's Desktop. We immediately clicked Start, Control Panel, Switch To Classic View, Administrative Tools, Computer Management, and Disk Management to verify our RAID type and format our partitions. The RAID showed up as one drive, Disk 0, with about half of our drives' total capacity, 305GB. We right-clicked Disk 0 and selected Properties, which told us that Windows considered it a RAID 0+1. However, Disk Management didn't consider any of the drives fault tolerant, which was confusing. We right-clicked the E: and F: partitions in turn, formatted them with NTFS, and then exited Disk Management.

There was one more thing to check. We put the DFI motherboard's installation CD in the optical drive, clicked Tools when the GUI popped up, and chose SIL3114 RAID Utility. This installed Silicon Image's SATARaid utility, which, when launched, put a blue icon in the System Tray by the clock. We double-clicked this to open SATARaid's GUI and then clicked Set 0. SATARaid told us that we had built a RAID 0+1 after all. We clicked the Members tab, and it showed us that indeed we had a mirrored set of striped pairs. Case closed: RAID 0+1.

As always, refer to the other RAID articles in this section for further details on the components we used and how we put them together. Together with "Lowest-Priced Terabyte System" on page 108, these articles will give you a fairly thorough overview of multidrive PC building.

Testing

This PC's results don't compare directly to those of our RAID 0 and 1 PCs, as those two systems had Athlon 64s and another motherboard. However, this RAID 0+1 computer is very similar to the RAID 5 and terabyte PCs in the following articles, albeit with different hard drives.

One surprise was how fast the IOmeter scores were compared to the other PCs'. Silicon Image's 3112 was the fastest SATA controller at its introduction, so perhaps the 3114 on our DFI board holds a similar speed advantage over the VIA 8237 southbridge on our RAID 0 and 1 systems—despite the VIA's faster non-PCI pipe to a speedier CPU.

Finally, we disconnected two drives to make a RAID 0 for comparison, as reported in our "Benchmark Scores" chart. RAID 0+1 was just a hair slower than the RAID 0 champ, yet vastly safer.

Final Remarks

Despite using so many hard drives, RAID 0+1 is actually cheaper than some more efficient types of RAID because it often doesn't need a special RAID controller card, depending on the motherboard. With a good power supply and a roomy case, you could enjoy high speed without sacrificing data safety. That's having your cake and eating it, too. RS

by Marty Sems

RAID 5 For Slightly More Than $1,000

This Parity Will Make You Smile

Build #25 Skill Level: 1 2 3 4 5 *Master*

We had to scrounge some SDRAM because our Promise RAID card didn't come with any. Thank heaven it passed Promise's memory test.

Fault tolerance doesn't have to cut your storage space in half. Unfortunately, with the RAIDs supported by many motherboards, such as RAIDs 1 and 0+1, that's exactly what happens. RAIDs 1 and 0+1 only leave you with 50% of your hard drives' capacity, thanks to their 1:1 mirroring of your data.

There's another option besides giving up data redundancy for RAID 0's 100% capacity. If you're willing to spend a couple hundred dollars on a controller card, you can build a fault-tolerant, relatively fast RAID that provides 66% or even 75% usable space. It's called RAID 5.

Goal

Instead of mirroring data, RAID 5 stores parity (error-checking) information. If there's an error or bit corruption, the parity data should catch it, and the RAID controller should correct it. All data and ECC are striped over three or more hard drives, which speeds up reads and writes.

Parity data takes up less space than mirrored data, so a RAID 5 can yield a total capacity of the sum of its drives, less one. As with other types of RAIDs, if you use differently sized drives, you'll lose access to the bigger drives' storage space above the smallest drive's capacity. To paraphrase controller vendor Promise, your RAID 5 will be the smallest drive's capacity times the total number of drives, minus one.

RAID 5's Achilles' heel is that it takes a lot of computational horsepower to maintain all that parity info, called XOR processing. If a motherboard supported RAID 5 without a dedicated processing unit, it would force the CPU to do much more work, slowing down the system. For desktop PCs, the best medicine is a RAID 5 controller card, such as the Promise FastTrak S150 SX4 we bought ($156; www.promise.com). Here's how we built a PC around that card for just more than $1,000, plus tax and shipping.

Background

Our Promise FastTrak S150 SX4 card packed four SATA ports, plus support for RAIDs 5, 0, 1, 0+1, and JBOD. It also came with four SATA data cables, adapters for four SATA power connectors, a printed quick start guide, a users manual on CD, and a driver diskette.

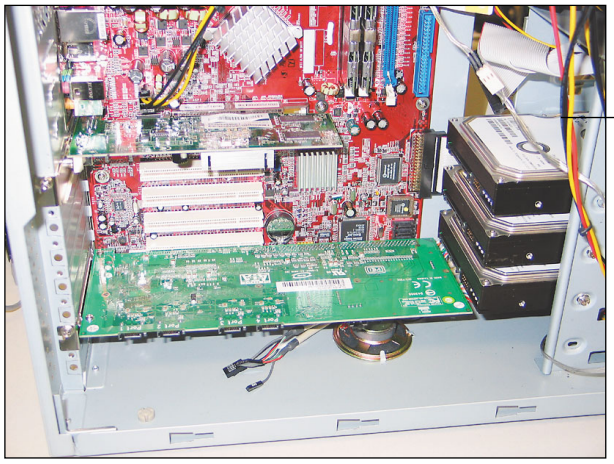
What the Promise card did *not* come with at $156 was the stick of RAM necessary to make the card work. And it wouldn't accept DDR, either; it required a 168-pin stick of older SDRAM, which has gone up in price because no one makes a lot of it anymore. We heard a "yay" from the system administrator who wants to choose her own RAM, but a serious "boo" from the hapless consumer who didn't notice the fine print when he bought the card. We dug around in our derelict silicon locker and liberated a 128MB stick of PC133. Factor in $20 or more if you have to buy one of these. (Promise released a version with 64MB of RAM included, the FastTrak S150 SX4-M [price unavailable], after we ordered our parts.)

The Promise card works best with 66MHz PCI slots found on server motherboards, but it will also work with the

33MHz PCI bus on most desktop boards, too. You shouldn't notice too much of a limitation from the 133MBps theoretical cap on a 33MHz slot, although the 266MBps of a 66MHz slot would probably allow faster throughput with current hard drives.

Although we used three Maxtor 6Y080M0 Serial ATA 80GB hard drives to keep costs down, you can add a fourth drive for even better performance. The Antec True430 power supply we bought is strong enough for a four-drive system. You can't really tell a good power supply before using it, but we will say that we've never encountered a high-quality PSU that didn't weigh much. Additional coil windings and internal heat dissipation sinks tend to help a decent PSU cope with surges and power spikes that would kill a lesser unit. Antec, Enermax, and Fortron all make reputable power supplies.

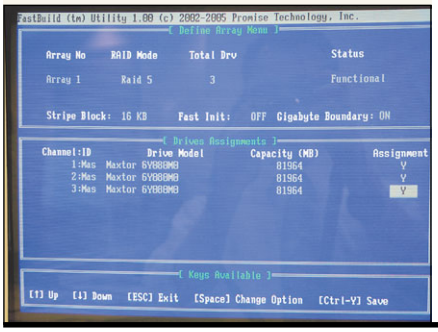
We've discussed our rationales for the other parts we chose for this PC in the other RAID and terabyte articles in this section, so we'll skip them here. However, we should mention that our $64 copies of Windows XP Home that we bought online were just that: copies. They didn't have Microsoft's blue and green, barcoded, and hologrammed Certificate of Authenticity sticker. Worse, a fellow writer found that his copy's product key was already activated somewhere. We got our money back and spent $26 more on legitimate CDs.



Talk about a long expansion card. Our Promise FastTrak card almost touched our hard drives in this case.

Time-saver

When you're creating a RAID 5 using Promise's FastBuild Utility, always set FastInit to On. This synchronizes the drives for top performance. We didn't do this the first time we built this system, and it cut our RAID's speed in half. ▲



RAID 5

Minimum Number Of Drives	Total Capacity	Benefits	Drawbacks
Three	Sum of all drives minus one	Speed between RAID 1 and RAID 0+1, yet more capacity; fault-tolerant	Usually requires a dedicated controller card

The Build

One gripe we had about this build is that you'll need access to a working computer. You'll also need to create a bootable floppy disk by right-clicking it in Windows Explorer, selecting Format, and choosing Create An MS-DOS Startup Disk. Building our RAID 5 was a little different from assembling our other PCs in this section, so refer to those articles for details and tips we didn't have room to include here.

First, we took the existing power supply out of our RaidMax case but didn't install the Antec just yet. We added a Compuman 80mm case fan in front of the 3.5-inch hard drive bays using two small bolts and motherboard standoffs as nuts, first flattening a raised section in our way with a stout bolt, nut, and washers. If you do this, make sure the fan blows into the case and 3.5-inch bays.

Next, we snapped the DFI motherboard's chromed I/O shield into the rear of the case. We then screwed standoffs into the case and mounted the mainboard on them. We installed the Athlon XP processor and its heatsink and connected the sink fan's power cable to the CPU FAN header on the motherboard. Once the heatsink was attached, we could carefully install the Antec power supply and connect its 20-pin and 4-pin power cables to the DFI board. If you install the PSU before this particular board, you'll have a terrible time trying to mount the heatsink.

Our AOpen CD-RW and Sony floppy drive went in next with four screws each. We popped out a 5.25-inch and a 3.5-inch plate in the case's plastic front panel to accommodate the drives. We added power cables and then ran data cables from the drives to the motherboard.

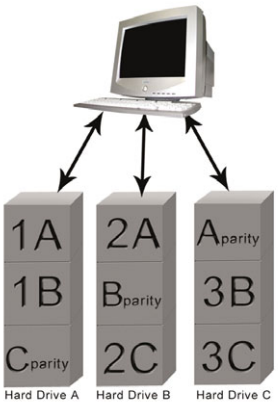
Speaking of the front panel, the DFI manual guided us to connect the panel's switches, LEDs, and USB ports to the proper headers on the motherboard. Next, we pressed our two sticks of DDR memory into slots DIMM1 and DIMM2. Your motherboard's manual will tell you which slots to put your RAM in; they're usually the two slots closest to the CPU. These days, it's better to buy RAM in matching pairs than singly, as many CPUs and motherboard chipsets can work faster with even numbers of DIMMs instead of one or three. Our Athlon XP and nForce2 chipset are examples.

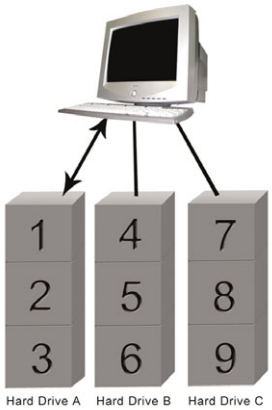
After we installed our Radeon 9200 SE video card, we connected it to our monitor via VGA cable. Two AC power cables later, we could start our PC. We immediately pressed DELETE to enter its BIOS settings, where we set the S-ATA Or SCSI Card Boot field to SCSI Card (BIOSes often consider SATA drives as SCSI devices for system configuration purposes). We also

RAID 5

A RAID 5 stripes data to most hard drives but writes parity (error-checking) information on the last drive in a shifting series. Splitting the parity data among the drives lets RAID 5 offer great speed and fault tolerance without sacrificing much capacity.

Capacity: A + B + C – one drive





A PC moves data to/from one unRAIDed hard drive at a time. Data isn't backed up, nor can it move as fast as in a RAID 5, but the computer can use the total capacity of all drives.

Capacity: A + B + C

set the Init Display First field to Onboard/AGP; set the clock and date; and rearranged the boot devices to Floppy, CD-ROM, and SCSI, in that order. We saved our changes, exited, and shut down the PC.

Platter matters. It was now time to slide our four hard drives into the lower 3.5-inch bay, securing them with four screws apiece. Metal tabs in the case kept the drives about half an inch apart for cooling purposes, letting our Compuman fan do its job. Speaking of fans, we flipped the RaidMax case's side panel fan to blow inward, too. The power supply's fan would provide exhaust airflow, and rear case perforations would let the remaining air pressure, and heat, escape.

We put in the hard drives before the long Promise card so that we would have an easier time maneuvering them into place. In fact, the card is so long that when installed, it almost touches the rear of the hard drives in this case. We thought about mounting it in the bottom PCI slot, so as not to interfere with airflow through the case. However, this wouldn't have let the card or its RAM ventilate. We compromised and stuck the card into the next-to-bottom slot, first pushing out that slot's knockout plate in the case. One screw held the card's bracket down.

Next, we connected SATA data cables to the drives and to the Promise card's ports 1, 2, and 3. Note that because the card will manage our RAID 5, the hard drives will connect to it instead of the motherboard. We also powered the drives with 4-pin Molex leads from our Antec supply, ignoring its two SATA power hookups (use one type of power connection or the other). Promise said to connect our case's hard drive LED cable (HDD LED) to the FastTrak card instead of the motherboard, but we couldn't find any header for it on the card.

FastBuild. We started the PC, pressing CTRL-F when prompted to enter Promise's FastBuild utility. We selected 2 to Define Array and then pressed ENTER to select Array 1. You can use the Spacebar to change the RAID type, but we left it at RAID 5 for this article. Using the indicated navigation keys, we left Stripe Block at the default 64KB per Promise's recommendation, although a 16KB block size would have stored our data more efficiently. This setting determines the granularity of the data blocks the drives will store files in, which means you'll get more usable storage space with smaller blocks. Next, we changed FastInit to On. If you neglect to do this with a RAID 5 on this card, your array will be very slow—slower than a single hard drive.

We left Gigabyte Boundary enabled. This lets you replace a failed drive with another that has slightly more or less actual storage space, within 1GB, such as a Western Digital 80GB in an array built with Maxtor 80GBs. Next, we arrowed down to Assignment and used the Spacebar to change each drive from N to Y. Finally, we pressed CTRL-Y to save our new array, which FastBuild assumed would be the boot device. We

Parts List

Unexpected expenses, such as the 128MB of SDRAM and the pricier WinXP CD that replaced our counterfeit faker, nudged our RAID 5 over the $1,000 line. Add another $83 for a fourth hard drive, and you'll have a substantially faster system with 240GB.

Component	Model	Price
Case	RaidMax 278WBP Mirage ATX Mid Tower	$38
Motherboard	DFI NFII Ultra Infinity	$86
Processor	Athlon XP 2000+ 266MHz retail	$57
Memory	256MB MemoryPRO (2x128MB) DDR400 PC3200	$52
Hard Drives	3x80GB Maxtor 6Y080M0 SATA ($83 each)	$249
Video Card	Sapphire Atlantis Radeon 9200 SE AGP 128MB TV-Out *	$43
Optical Drive	AOpen 52X/32X/52X Chameleon CD-RW	$26
Monitor	Samsung SyncMaster 753DF (17-inch, 1,280 x 1,024, 0.20mm)	$119
Floppy Drive	Sony MPF920ZCU1 3.5-inch 2HD Floppy Drive Internal	$5
Power Supply	Antec True430 430W	$59
Mouse	Logitech Optical Wheel Three-button Mouse	$9
Keyboard	Belkin ErgoBoard USB/PS/2	$16
Operating System	Windows XP Home Full OEM Version	$90
RAID card	Promise FastTrak S150 SX4	$157
Miscellaneous	128MB Module 168-pin PC133 SDRAM (for Promise card); Compuman 80mm Case Fan; Miscellaneous Bolts, Nuts *	$30
Total		**$1,034.70**

* Equipment previously purchased.

pressed ESC and *Y* to exit and reboot the system.

Because some RAM isn't suitable for use on the FastTrak card, Promise wants you to run a utility to test the memory after you install it. However, we couldn't find the unnamed utility that was ostensibly on the CD, so we had to download it from www.promise.com (click Support and Download and then search the Utility category for the FastTrak S150 SX4 and Windows). Furthermore, the utility is meant to be run from a diskette after you boot with a separate startup disk, which we told you how to make at the beginning of The Build section. We feel that Promise could have easily included this RAM-testing software preinstalled on a diskette, as it did with the drivers.

We unzipped the download using WinZip and then copied the three resulting files (Dos4gw.EXE, Memtest.EXE, and Readme.TXT) to a blank diskette. Next, we booted our nascent RAID 5 system into DOS with the startup diskette. When the A: prompt appeared, we swapped in the second diskette with the memory test on it. We typed memtest and pressed ENTER. Fortunately, our DIMM passed the test. If it hadn't, we could have located another stick of RAM relatively easily. You might not have such an easy time if you have to return a DIMM you've bought. It's probably worth it to simply buy the "M" variant of Promise's card, with memory included, in the first place.

We ejected the diskette, stuck the WinXP CD in the optical drive, and rebooted. Very soon, we had to press F6 to install third-party SCSI or RAID drivers. When Windows Setup asked us, we inserted Promise's driver diskette and followed the instructions. You may have to do this whenever you install WinXP on a SATA drive or RAID. Later in Windows Setup, we created a 10GB NTFS partition for WinXP, another 10GB drive letter for our apps, and a 134GB partition for our data. The roughly 160GB total available space reflected RAID 5's A+B+C-one drive capacity (80+80+80-80=160GB).

USB trouble. Twice during WinXP installation, we had to tell Setup to use the Promise drivers regardless of its out-of-date assertion that they weren't approved by Microsoft. Oddly, we lost support for our USB keyboard and mouse on the second occasion, despite USB keyboard support being enabled in the BIOS settings. At length, we had to press the PC's front reset button and let Windows Setup try that phase again. It didn't work until we used a different keyboard with a PS/2 connection and an adapter to connect the mouse to a PS/2 port. Even today, more motherboard BIOSes support PS/2 than USB before an OS loads, making USB keyboards and mice less attractive.

After Windows finished installing, we clicked Start, Control Panel, Switch To Classic View, Administrative Tools, Computer Management, and Disk Management. Here we right-clicked and Formatted the D: and E: partitions we'd created in Windows Setup, which automatically formats C: as it installs WinXP. Next, after installing DFI's motherboard drivers and updates, we updated the Promise card with new drivers from www.promise.com.

Benchmark Scores, RAID 5

Our RAID 5 was faster than a RAID 1, yet not as speedy as a RAID 0 or 0+1. Note the difference with the Radeon 9200 SE video card: one-third the 3DMark03 score of the full 9200. We ran PCMark04 (version 1.2.0, with Windows Media Player 9) and 3DMark03 (build 340, with DirectX 9.0b) at default settings; HD Tach 3 with 32MB zones over the entire 160GB array; IOmeter 2003.5.10's File Server test at one user, 16 outstanding I/Os; IOmeter's Web Server test at four users, 64 total outstanding I/Os; both run on the second 10GB partition of the RAID. The ATI video card drivers were Catalyst 4.7. Although it would blow our budget, we built a 480GB RAID 5 out of four Maxtor 6Y160M0 160GB drives for comparison.

	Three 80GB Drives (160GB total)	Four 160GB Drives (480GB total)
PCMark04		
System	2496	2489
CPU	2799	2800
Memory	1944	1939
Graphics	601	600
Hard Drives	3713	4151
3DMark03	443	442
HD Tach 3		
Average read (MBps)	64.4	78.4
Maximum read (MBps)	108	108
Burst read (MBps)	113.9	113.9
Random access (ms)	15.2	14.3
IOmeter (inputs/outputs per second)		
File server	205.32	297.02
Web server	268.78	375.13

Testing

HD Tach showed maximum reads close to our RAID 0+1's and average reads about 20% better than RAID 1 or single drives. IOmeter also had a field day, reporting top scores in both tests. We think that the dedicated number-crunching hardware on the Promise card helped to route multiple data requests, which is what IOmeter tracks. However, PCMark wasn't impressed with our RAID to judge by its Hard Drive test score, which conspired with the weaker Radeon 9200 SE to bring the overall System score down.

In sum, RAID 5 falls between RAID 1 and RAID 0+1 in speed yet offers more usable capacity than either one. A fourth hard drive would have made our RAID 5 a little faster, Promise says, as would have a motherboard with 66MHz PCI slots.

Just for shucks and giggles, we tried a RAID 5 with four SATA drives to see whether Promise was right. We didn't have a fourth 80GB drive, so we used four Maxtor 6Y160M0 160GBs ($420 total, or $171 extra) with similar characteristics. Promise was dead on: 22% faster average reads, a 40% better Web server score, and a whopping 45% higher file server rating.

Final Remarks

If you're running a server, a four-drive RAID 5 is an outstanding choice. A three-drive system like the one we built isn't bad, but a fourth drive really uncorks performance. RAID 5 is also interesting in that you'll be able to use the full capacity of any hard drive you add to it. RS

by Marty Sems

LOWEST-PRICED TERABYTE SYSTEM

A TB Titan For The Thrifty

Build #26 Skill Level: 1 2 3 4 5 ***Novice***

In the movie "Field of Dreams," a dead baseball player in a cornfield convinced Kevin Costner to turn his south forty into a ball field. The ghost vaguely promised, "If you build it, they will come." Apparently, he meant that other deceased ball players would show up for an exhibition game, and presumably paying fans would drive out and park in the beans.

You've probably noticed that a similar thing happens with computers. If you have the hard drive space, "they" will come: music files, video clips, and digital photos. Applications often absorb 25MB, or many times that amount in the case of Microsoft Office. And games are worse; one of the system requirements of the popular Far Cry is 4GB of free drive space.

Goal

The silver lining to the storage cloud is the fact that hard drive space is cheap. How cheap? Well, here's our recipe for a system with a full terabyte (1TB, or 1,000GB) of storage for around $1,300, plus tax and shipping. And as usual, that includes a monitor, keyboard, mouse, and Windows XP Home Edition.

With 1,000GB at your beck and call, you could do an awful lot of video editing or sound mixing. Why not archive multi-megapixel family photos at your camera's highest resolution? You could make a multiboot system with other OSes, such as Linux or even Win98 for compatibility with old apps and games. Finally, you could construct a file server for backing up the PCs on your network or a media server to stream music and movies to other hardware around the house.

Really, a terabyte is an arbitrary amount. There's little practical reason to build 1TB into a system rather than 900GB or 1.2TB, besides the way "a terabyte" rolls off your tongue. Feel free to swap this PC's hard drives or other components as you see fit.

Background

For this system, we chose four Western Digital WD2500JD 250GB hard drives at $169 each ($676 total). These included large 8MB cache buffers and 7,200rpm spindle speeds, both of which are speed improvements that don't cost much more than 2MB caches and 5,400rpm speeds.

At this writing, four 250GB hard drives pose a more cost-effective way to get a terabyte than multiple 300GB or 400GB models. Seagate says that its new 500GB NL35 Series drives for the Fibre Channel server interface will debut before the end of Q4. However, you'll have to wait until next year for a SATA NL35 for desktop PCs.

When you plan a PC with four hard drives, you'll need to budget for a power supply that has the strength to run them all. This manifests itself as overall wattage (W) and the amperage available on the supply's 12-volt rail (circuit). Our computer case came with a 350W power supply with a mere 10A on the 12V rail. That was good enough for two hard drives, an Athlon 64, a DVD drive, and a low-end graphics card in the RAID 0 and 1 articles. However, it couldn't have booted our terabyte PC with two extra hard drives, so we upgraded to an Antec True Power 430W with 26A at 12V. If your power supply is too weak, it will keep your PC from completing the startup process until you disconnect a drive or two and reboot. Antec, Enermax, and Fortron power supplies all have reliable reputations. Some cheaper brands can suddenly fail at the first minor power surge.

It takes three or four drives today, such as these 250GB beauties from Western Digital, to cross the 1TB threshold. Early next year, you'll be able to get there with just two Seagates.

As for a case, our well-used RaidMax 278WBP Mirage from the previous articles gave us plenty of drive bays at a low price. This PC needed at least four internal 3.5-inch bays for the hard drives, one external 3.5-inch bay for the floppy drive, and an external 5.25-inch bay for the CD-RW. In a pinch, you can mount a hard drive in an unused 5.25-inch bay using brackets from a computer store.

Our drives laughed at the 350W power supply that came with our RaidMax case. Installation of our new Antec was a snap.

We made some compromises to make this the "lowest-cost" terabyte system, using AMD's last-generation, but still potent, Athlon XP 2000+. That chip, plus DFI's inexpensive NFII Ultra Infinity motherboard, gave us speed similar to a 2GHz Pentium 4 without the higher price of the Intel chip/mobo route. Its 266MHz frontside bus doesn't thrill us, though. An Athlon XP 2500+ with 333MHz cost just $22 more. However, a 400MHz FSB chip cost three times as much at this writing.

DFI was a brand this writer had never worked with until this article. The NFII motherboard's four SATA ports saved us from having to buy extra SATA ports on an adapter card. Even better, the motherboard supported RAIDs 0, 1, and 0+1, along with FireWire and 10/100Mbps Ethernet. It also came endowed with SPDIF audio input and output. However, instead of the promised NVIDIA SPP southbridge with SoundStorm audio and Dolby Digital 5.1 encoding, DFI gave us NVIDIA's MCP-T and a Realtek ALC650 sound chip. The Silicon Image RAID utility purported to support RAID 10—which turned out to be a typo for RAID 0+1—but not JBOD as the motherboard's box claimed.

The rest of our shopping list reflected good deals we found with name brands, nice features, and low prices. For example, the $69 ATI Radeon 9200 video card won't interest any gamers, but it does offer DirectX 8.1 support and an S-Video TV output jack. It replaced a defective $43 Radeon 9200 SE we tried. A truly rock-bottom 2D card would've cost $12 or less. In a similar vein, we could've paid half as much for a CD-ROM as we did for our $26 AOpen CD-RW, but we decided that CD burning is just too useful to leave out.

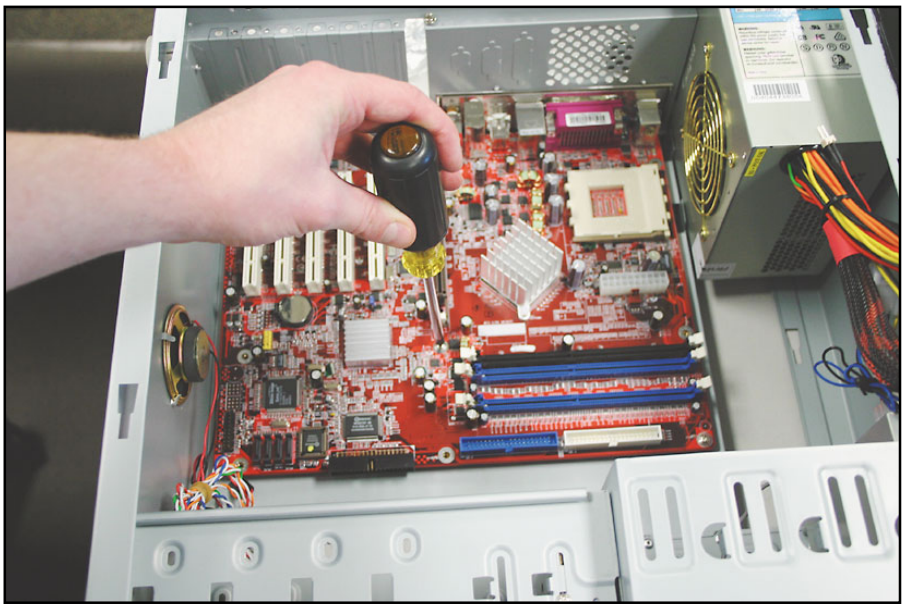
The Build

Before we installed anything delicate in our RaidMax case, we got the heavy stuff out of the way. We unbolted the power supply that came with the case and set it aside. A few screws later, we had our new Antec power supply mounted in its place. We touched the bare metal of the case occasionally to dispel harmful static electricity as we worked.

Among others, the DFI motherboard came with two SATA data cables, two SATA power adapters, and a floppy cable, plus SATA RAID drivers on diskette. We clipped the board's silver I/O shield into the rear of the case, poking out a few knockouts to match the audio and LAN ports on the motherboard. Next, we installed standoffs in the case according to the NFII's mounting hole pattern and then bolted the motherboard in place. We had to bend a few grounding tabs on the I/O shield to clear the mouse and keyboard ports.

Next, we installed the microprocessor. Two corners of the Athlon XP had one fewer pin, marked with a triangle and a letter T on our 2000+ example. These missing pins helped us orient the chip the right way. We lifted the CPU socket's side lever to a 90-degree angle before fully settling the Athlon in the holes and then lowered the lever until it clicked. This lever locked the chip in place.

AMD included a heatsink/fan combo with our retail-boxed Athlon XP. It clung to the CPU via a metal clip, which grabbed three tabs on either side of the socket. The bottom of the sink had a recessed section meant for the high plateau of the CPU socket, so there was only one way to mount it that would let the sink properly contact the processor. Unfortunately, that orientation on this motherboard put the mounting clip too close to the power supply to reach with our flat-nosed screwdriver, so we quickly removed the Antec rather than wrestle with a tight spot. We slipped the smooth end of the heatsink's mounting clip over the socket's three tabs facing the middle of the board and then carefully maneuvered the other end of the clip over the opposite tabs with our screwdriver. Be careful here, and use a screwdriver that fits the heatsink clip. Double-check that the clip is held by all six socket tabs, and don't forget to connect the fan to the CPU FAN header. When we



Motherboard mounting holes are rimmed with silver metal, so don't use the wrong holes. Here, we're securing our DFI board into the case.

finished, the Antec power supply went back into place.

At this point, we attached the power supply's 20-pin and 4-pin connectors to the motherboard, as well as the case speaker, front USB ports, power and reset switches, and power and hard drive LEDs. DFI's manual showed us how. Next, in went the video card, which we bolted to the back of the case and connected to our monitor's VGA cable.

The CD-RW and floppy drives installed next with four screws each, along with their power and data cables. We ran the former's CD audio cable down to the input on the lower left of the motherboard. The CD audio input's location was as bad as the CPU socket's proximity to the power supply; our cable barely reached. If yours doesn't, move the CD-RW to a lower bay.

DOS boot. The mouse and keyboard hooked up next so we could do a trial boot with a Windows Me system diskette we had on hand. Everything seemed to work. Next, we rebooted and pressed DEL at the prompt to enter the NFII board's BIOS Setup. Here, in various settings categories, we set the clock and date; rearranged the boot devices to Floppy, CD-ROM, and SCSI (BIOSes often consider SATA drives as SCSI devices for system configuration purposes), in that order; and set the Init Display First field to AGP. We saved our changes and exited and then shut off the computer.

Carefully, we secured our four hard drives in the 3.5-inch bay using four screws each. Handle hard drives as if they're eggs; any drop or knock that would crack an egg is probably enough to damage some drives.

We had some trouble getting DFI's red SATA data cables connected without breaking anything, but the two grey SATA cables we borrowed from our EPoX motherboard were easier to attach. You might need to buy a few extra SATA cables for your system, as most motherboards include two or fewer. For power, we attached the Antec supply's two SATA power connectors to two of the drives and then used DFI's Y-shaped adapter to convert a 4-pin Molex power lead to SATA-style connectors for the other two hard disks.

Next, we restarted the PC, quickly slipping the WinXP CD into the optical drive. The system booted into Windows Setup. Very soon, we had to press F6 when Setup momentarily asked us for any third-party SCSI or RAID drivers. We supplied the SATA RAID driver diskette DFI had included and followed the directions. This driver worked, although Windows Setup told us twice later that Microsoft hadn't approved the drivers.

Partitioning and formatting. When Windows Setup asked us if we wanted to make any partitions, we agreed, arrowing down to each of our four drives and pressing the *C* key and ENTER. On the first hard drive, we made a 10GB partition for WinXP (drive letter C:), a 10GB section for our applications (D:), and a partition of the remaining space for data (E:). We partitioned each of the other drives into single drive letters with full capacity, which Windows variously reported as around 238GB or 232GB. The difference between these and the 250GB advertised space comes from counting bytes, KBs, MBs, or GBs by units of the correct 1,024 versus the 1,000 unit most people use.

Parts List

Half the cost of this PC is its four hard drives. Currently, four 250GB drives offer the most practical road to a full terabyte.

Component	Model	Price
Case	RaidMax 278WBP Mirage ATX Mid Tower	$38
Motherboard	DFI NFII Ultra Infinity	$86
Processor	Athlon XP 2000+ 266MHz retail	$57
Memory	256MB MemoryPRO (2x128MB) DDR400 PC3200	$52
Hard Drives	4x 250GB WD2500JD SATA (7,200rpm, 8MB cache)	$676
Video Card	ATI Radeon 9200 AGP 128MB TV-Out *	$69
Optical Drive	AOpen 52X/32X/52X Chameleon CD-RW	$26
Monitor	Samsung SyncMaster 753DF (17-inch, 1,280 x 1,024, 0.20mm)	$119
Floppy Drive	Sony MPF920ZCU1 3.5in 2HD Floppy Drive Internal	$4.88
Power Supply	Antec True430 430W	$59
Mouse	Logitech optical Wheel 3-Button Mouse	$8.59
Keyboard	Belkin ErgoBoard USB / PS/2	$16
Operating System	Windows XP Home Full OEM version	$90
Miscellaneous	Compuman 80mm case fan; two extra SATA cables; misc. bolts, nuts *	$15
Total		**$1,316.47**

* Equipment previously purchased.

Watch Out

Our 256MB of "Micron or major brand" DDR memory turned out to be MemoryPRO brand with Elixir chips. We shouldn't have been surprised. Lots of discount hardware vendors drop the names of good RAM manufacturers such as Crucial/Micron and Corsair in order to grab attention at pricing sites such as Pricegrabber.com and Pricewatch.com. Usually, you'll wind up with the "major brand" alternative which, as in our case, may be made by a company you've never heard of.

Close inspection showed us that not only did the DIMM modules' metal heat-spreader not touch the silicon memory chips, but that the peel-and-stick thermal tape on the inside of the heatspreader was still unpeeled. Despite the fact that this arrangement would keep the RAM hotter than if it had no heatspreader at all, there was a "warranty void if removed" label covering one of the spreader's retention clips on each DIMM. In other words, watch the fine print on RAM bargains. ▲

After the Windows installation completed, we still had to format the D: and subsequent partitions using Disk Management (click Start, Control Panel, Administrative Tools, Computer Management, and Disk Management) before we could store any data on them. If a partition doesn't have a file system, such as NTFS or FAT32, right-click it and select Format. You can choose the allocation unit, or cluster, size here. Small allocation units, such as 512 bytes, will let you store more data than larger ones, such as 64KB. A 64KB cluster size means that files smaller than that will still use up 64KB each, wasting space. However, larger clusters will let the drive run slightly faster than will smaller allocation units, so we often choose 2KB or 4KB sizes.

You can also make partitions in Disk Management if you didn't in Windows Setup. Just remember to format each partition after you make it so it can store data.

Another way to set up a terabyte system is to lump the drives into a JBOD RAID configuration. A JBOD can span all the drives into one big terabyte partition, if you like. You can subdivide this C: drive into other drive letters, of course, and you probably should for efficiency's sake. Such a big partition would be really, really inefficient, with large cluster sizes and lots of wasted space. Unfortunately, as we mentioned, our motherboard didn't offer JBOD. However, WinXP offers a method of making a virtual JBOD called a dynamic disk. Like RAID 0, JBOD has none of the data redundancy of a real RAID. WinXP's dynamic disk, meanwhile, is vulnerable to the loss of any one hard drive.

Odds and ends. We finished up with an installation of DFI's FireWire bracket, which gave us a 400MBps rear port. We also installed the motherboard drivers from the included CD, plus Windows Updates and drivers for our video card. As for firewall and antivirus software, check www.zonealarm.com and free.grisoft.com for free versions if none came with your motherboard's software bundle.

After some testing, we decided that the Fan Only power lead on the Antec True430 supply didn't give our case fans enough voltage to spin at the speeds we wanted. The four drives and Nforce2 chipset heatsinks were all heating the case interior a little too much for our tastes. We linked the fans to the power lead serving the CD-RW drive, and both blowers started pulling their weight.

System Notes

We ran PCMark04 (version 1.2.0, with Windows Media Player 9) and 3DMark03 (build 340, with DirectX 9.0) at default settings; HD Tach 3 with 32MB zones over the entire first 250GB drive; IOmeter 2003.5.10's File Server test at one user, 16 outstanding I/Os; IOmeter's Web Server test at four users, 64 total outstanding I/Os; both run on the second 10GB partition of the first hard drive. The ATI video card drivers were Catalyst 4.7.

PCMark04	
System	2756
CPU	2806
Memory	1938
Graphics	1277
Hard Drives	4451
3DMark03	1154
HD Tach 3	
Average read (MBps)	50
Maximum read (MBps)	59
Burst read (MBps)	77.7
Random access (ms)	13.4
IOmeter (inputs/outputs per second)	
File server	127.68
Web server	155.96

Testing

Overall, the terabyte PC's results serve as a baseline to contrast with our other RAID systems built upon this motherboard in the previous two articles, with the caveat of different CPUs. This computer's hard drive test results are equivalent to a single-drive system's.

One change from our testing methodology with the RAID 0 and 1 systems in the beginning of this section is the fact that we ran HD Tach over the entire 250GB of the first drive instead of just the first 10GB partition. Still, the Western Digital 250GB gave us read rates very similar to a single or RAID 1 Maxtor 160GB, with a quicker random access time but much-reduced burst reads. The latter is likely more to do with the change in motherboards, as the Silicon Image controller we used on the DFI board had to use the slower 133MBps PCI bus, unlike the 150MBps SATA controller built into the VIA southbridge on the EPoX board.

System Notes

Our budget terabyte system in the price/performance sweet spot uses last-gen muscle.
AMD Athlon XP 2000+ 1.67GHz, 266MHz frontside bus, 128KB L2 cache, 462-pin (Socket A)
DFI NFII Ultra Infinity motherboard
256MB (2x128MB) MemoryPRO DDR400 SDRAM, dual-channel
1TB (4x250GB Western Digital WD2500JD hard drives), 7,200rpm, 8MB caches
AOpen 52X/32X/52X Chameleon CD-RW
10/100MBps LAN
SPDIF output and input; 5.1-channel Realtek ALC650 audio
Four SATA ports
FireWire 400MBps (IEEE 1394)
16.5h x 8w x 19d inches; 29 lbs.

Final Remarks

As 400GB drives fall in price, it will become more cost-effective to build a terabyte with three hard drives instead of four. That's a definite plus from the standpoint of power consumption, heat output, and overall weight. And you'll be able to trim your terabytical titan down to two drives next year if Seagate delivers on its promise of a 500GB SATA unit. Don't expect that to be a budget system, however; cutting-edge capacities always carry a price premium. RS

by Marty Sems

BEST STANDARD SMALL-FORM-FACTOR PC UNDER $1,500

Build A High-Powered PC That Doesn't Need Space

Build #27 Skill Level: 1 **2** 3 4 5 *Apprentice*

Modded systems are great if you want to wow your competitors' eyeballs at a LAN party. But lights, windows, and other visual alterations are more about style than substance, and not only are they not particularly useful, they can also add substantial heft to your system. Why not take the opposite strategy and build a super-small system instead?

Those are myriad reasons you might consider building an SFF (small-form-factor) PC. Maybe you're fed up with your electronics consuming too much office space. Perhaps you're sick to death of lugging around a full-sized PC case and monitor to weekly gaming get-togethers. Whatever your situation, reduced-size computers are becoming more popular with users who need a powerful computer in a smaller shell.

Goal

You might think that switching to a mini-PC will cost you far more than a regular desktop machine. You will definitely pay a little extra for one or two components in order to make a small PC a reality, but you won't spend hundreds of extra dollars for the privilege of saving some desk space.

Our goal was to build a fast PC that could run most graphics-intensive games without any major hiccups and that would have few problems switching to other tasks, from word processing to digital video editing. We wanted to build this PC for $1,500 or less, and though we weren't sure how much power we'd be able to squeeze into a small PC for this kind of money, we think you'll be pleasantly surprised with our end result.

Background

The key components in a small-form-factor computer are obviously those that consume the most space in a traditional machine. A typical ATX form-factor motherboard wouldn't let us keep our system small, but the low-profile type of PC cases and motherboards used in corporate settings weren't powerful enough for our preferences.

We also didn't want to go too small. Mini-ATX and Mini-ITX components were tempting, but their size means we'd have to buy specialized parts that cost more than we wanted to spend. Thus, we opted to stick with small-form-factor components that would let us use mostly standard PC parts, just in a smaller area than usual.

Space-age Shuttle. Shuttle, which does big business by selling small-form-factor, barebones PCs, made our case and motherboard choice easier. The only potential problem was that most of these kinds of PCs are targeted to Intel users, and Intel CPUs tend to cost quite a bit more than their AMD counterparts. We did some digging, though, and found an AMD-compatible version called the SN85G4, which included a small case, preinstalled motherboard, CPU cooling system, and more. Better yet, not only could we use an AMD CPU, we could also use a 64-bit CPU Athlon for extra computing power.

This motherboard supported up to 2GB of DDR400 RAM and offered the choice of IDE and SATA hard drive connectors. In addition, this Shuttle had onboard audio, Ethernet, two USB ports, a FireWire port, one PCI slot, and an 8X AGP slot. All of these components were crammed into a case that was 7.5 inches high x 7.8 inches wide x 11.6 inches deep.

Watch Out

The Shuttle case and motherboard we bought came with an integrated power supply rated for 240 watts. Most standard-size PC cases contain power supplies rated for 300 watts or more, so, for a smaller power supply, plan to keep the number of drives and peripherals at a minimum for optimal operation. ▲

The case itself even had a front-mounted flash card reader that recognized six card formats. Shuttle did offer a version of this case without the flash card drive, but oddly, choosing the driveless case didn't mean we would get an empty drive bay for another component. Instead, we would've simply received an empty bay with a solid cover that renders this extra space practically useless.

For the heart of our system, we initially selected an AMD Athlon 64 3000+, even though the Shuttle board was designed to work with Athlon 64 CPUs as fast as the 3400+. This turned out to be a fortuitous spec because we found out later that our 3000+ never made it to our assembly desk. We snagged a co-worker's 3200+ instead. Not only did this CPU fit our budget, but it was a bit faster, too.

We wouldn't settle for less than 1GB of maximum-speed RAM in our little box. Unfortunately, the limited budget prevented us from pushing all the way to 2GB RAM, no matter the speed, and it also restricted us to RAM of less than cutting-edge gamer quality. That was fine with us. We settled on Kingston PC3200 ValueRAM. Our two modules cost well under $200.

Picking a video card wasn't as easy as we thought. We wanted a card worthy of today's most demanding games, but we were concerned that such a card wouldn't fit in the confines of our shrunken case. We were also mildly concerned about the power demands of such a card, especially considering that our Shuttle PSU was rated at 240 watts. In the end we decided to go for broke by installing an ATI Radeon 9800 Pro with 256MB of memory.

We decided to stick with a traditional IDE drive primarily to cut costs. With that in mind, we found a nice blend of large capacity and low cost in a 160GB Maxtor drive. Not only was this hard drive huge, but it was also cheap, costing us just over $100.

Monitor musings. We did not actually buy a monitor for this PC, but left a sizable gap in our budget for a high-quality monitor (and we definitely had a couple of specific models in mind when we listed a price in our chart). When we did our monitor shopping, we envisioned the perfect screen for our small-form-factor PC.

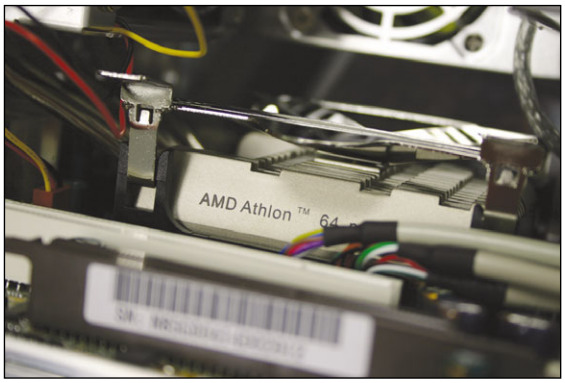
We couldn't understand buying a large CRT that would outweigh the CPU and its associated components and peripherals combined. The purpose of a small PC is to reduce the amount of space being used, and most 19-inch CRTs require their own ZIP codes.

Because we wanted our small system to be portable, we knew we needed a smaller monitor, preferably one that we could carry with one hand. That meant we had to choose an LCD. Unfortunately, 17-inch LCDs were far more expensive than the similarly sized CRTs that we could've ordered for less than $100; in fact, the cheapest 17-inch LCD monitor we found had a price tag of more than $300.

However, smaller LCDs were significantly less. After some careful searching, we found a few 15-inch LCD monitors that cost less than $230. One example was the Rosewill R500N, which had a native resolution of 1,024 x 768, 350:1 contrast ratio, and two built-in speakers.

The Build

After we dug out all of our components, it was time to put them together. First things first: We had to install our CPU. With most PCs, this part of the installation is an afterthought, but with our small-form-factor case, this task was complicated by the case's specially designed heatsink. This heatsink is connected to the case fan by four heatpipes to aid cooling, meaning you can't just yank the heatsink loose as you would with a typical PC.



A user-friendly clip secures the heatsink assembly to the top of the CPU. Press down firmly on the clip to remove it.

To get at the CPU socket we had to remove the entire Shuttle I.C.E. cooling

Parts List

We slightly exceeded our budget, but even with a more powerful CPU than we originally ordered, we're still well within range of $1,500.

Component	Model	Price
Case & Motherboard	Shuttle XPC SN85G4V2	$298
Processor	AMD Athlon 64 3200+ (ClawHammer core) OEM	$283
Memory	Kingston KVR400X64C3AK2/1G 1GB Kit DDR400	$175
Hard Drive	Maxtor 7,200rpm 160GB with 8MB cache	$104
Video Card	ATI Radeon 9800 Pro (256MB)	$265
Optical Drive	Samsung 2MB Cache 52X/32X/52X/16X CD-RW/DVD	$26
Monitor	Rosewill R500N 15-inch LCD	$239
Mouse & Keyboard	Logitech PS/2 keyboard and optical mouse	$25
Operating System	Windows XP Home full OEM version	$90
Miscellaneous*	Power supply splitter; screws and bolts	
Total		**$1,505.00**

* Previously purchased item

system, including the fan, heatpipes, and heatsink. Loosening these components was a matter of removing four screws—not the four interior screws, but the four thumbscrews on the back of the case.

After we removed these screws, we pulled out the CPU fan, being careful not to yank the fan power wires and bend the motherboard connectors. Then we pushed down on the rounded edge of the heatsink bracket while pulling out and up on the corner finger tabs, causing the bracket to let go of the CPU socket. We pulled out the bracket and then the entire heatpipe/heatsink assembly. Once we locked in our CPU and applied a layer of thermal grease, we reversed these steps to reinstall the cooling components.

We set about squeezing our hard drive into the case, only to find that there was a thin layer of glue securing a cable that stretched from the mobo to the front-mounted flash card reader—a cable that was thick enough to thwart our drive installation efforts. To continue, we carefully pulled the sticky flash card drive connector free. It turned out that this cable was the least of our concerns. Even with the cable out of the way, there wasn't enough room to maneuver the drive into its bay.

Then we realized that we would have to remove the entire drive rack to make this setup work. To remove the rack, we took out the two rack screws, slid the entire rack back an inch or so, and pulled it carefully out of the case. We secured the hard drive with screws, and to make sure we'd have an opening for our optical drive, we took out the metal plate covering the 5.25-inch drive bay. We didn't install this drive just yet, though, because doing so would've made it more difficult to reconnect the flash card drive cable.

We secured the drive rack in the case, connected the flash card drive cable, and using the IDE cable that Shuttle included, also connected the hard drive to the motherboard. We connected the IDE cable's blue plug to the blue IDE connector on the motherboard and the black plug to the back of the drive.

Then we were finally able to drop the optical drive into its place in the drive rack. We aligned the drive so that it was recessed and flush with the slanted portion of the drive bay face and used screws to keep it in place. Shuttle made it easy to connect the IDE cable for this drive, as this cable is already connected to the motherboard and tied down within reach of the drive's rear connector.

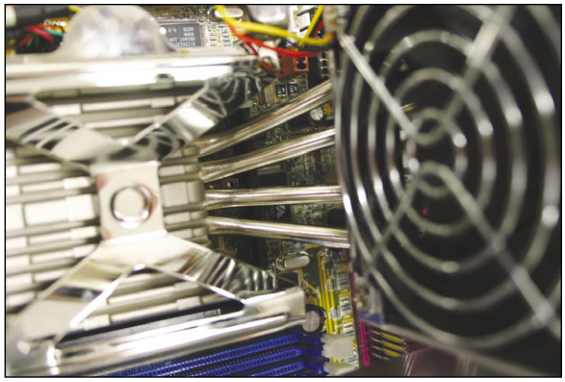
With all the primary components in place, we slipped the cooling system back into place. The fit was a little cramped for our fingers, but we didn't encounter any problems. Then we lowered the CPU fan place and connected it to the motherboard.

Because we wanted to use a high-end video card that required power from the PSU, we needed a splitter to make enough connectors; Shuttle included three PSU connectors in this case, but there wasn't one long enough to reach the length of the 9800 Pro. Once we had a splitter, we connected power to the drives, installed the video card, and plugged the power connecter to the card. Before we could slip the card into place, we had to remove both screws from the door covering the PCI slots. Doing so let us flip up this door, install the card, and then secure it with a screw. Then we clicked our DDR modules into the RAM slots next to the CPU.

Time-saver

Use Shuttle's manual to guide you through the component installation process. Because of the limited space in this case, you have to install your devices in a specific order; otherwise, you'll waste time reversing your steps to complete several tasks. ▲

System Notes	
Height	7.5 inches
Width	7.8 inches
Depth	11.6 inches
Weight	10 lbs
Features	
160GB Maxtor hard drive	
1GB Kingston DDR400 RAM	
8X AGP slot	
Two High-Speed USB 2.0 ports	
One FireWire port	
One PCI slot	
6-in-1 flash card reader built-in	
240-watt power supply	
Samsung 52X/32X/52X/16X CD-RW/DVD drive (2MB cache)	
Benchmarks	
PCMark04	3773
3DMark03	5587



The CPU heatsink connects to a radiator via four heatpipes, so to remove the heatsink, you have to take out the radiator and fan, too.

Testing

We plugged our mouse, keyboard, PSU cable, and video cable into the back of our tiny PC and hit the power button. The PC started up correctly, so we inserted our Windows XP CD and pressed the F1 key to continue the boot process. Setup began copying files with no problems.

We followed the on-screen instructions and answered a few basic questions regarding the installation. When prompted to select a destination for Windows files, we selected our blank hard drive, which we formatted using the NTFS Quick option. From there, the WinXP installation was a matter of following basic on-screen prompts.

Once our PC had a complete version of WinXP, we set out to resolve any driver issues we could find. Using the Device Manger, we located numerous yellow exclamation points that indicated driver

problems. We inserted the motherboard's CD, right-clicked each of these components, selected Properties, and then clicked Update Driver. WinXP found each driver it needed on the CD, and in cases where we had to select from a list of drivers, we examined the pathname and found a driver with a reference to WinXP.

Before we called our setup good, we double-checked our system speed by right-clicking the My Computer icon and then clicking Properties. Because we were using an Athlon 64 3200+, we expected to see a CPU speed of 2.2GHz, but unfortunately, WinXP reported a speed of only 1.99GHz. To set things right, we restarted the computer and entered the BIOS menu, only to find that the CPU speed options wouldn't let us push the processor any higher without engaging the overclocking options.

We scoured the Shuttle manual hoping to find an obscure jumper that needed to be adjusted for certain CPU speeds. We searched in vain for an updated version of the BIOS. We did everything we could think of to resolve our CPU speed conundrum, and finally, we gave up and emailed Shuttle's tech support, which ominously noted that we should expect to wait at least 72 hours.

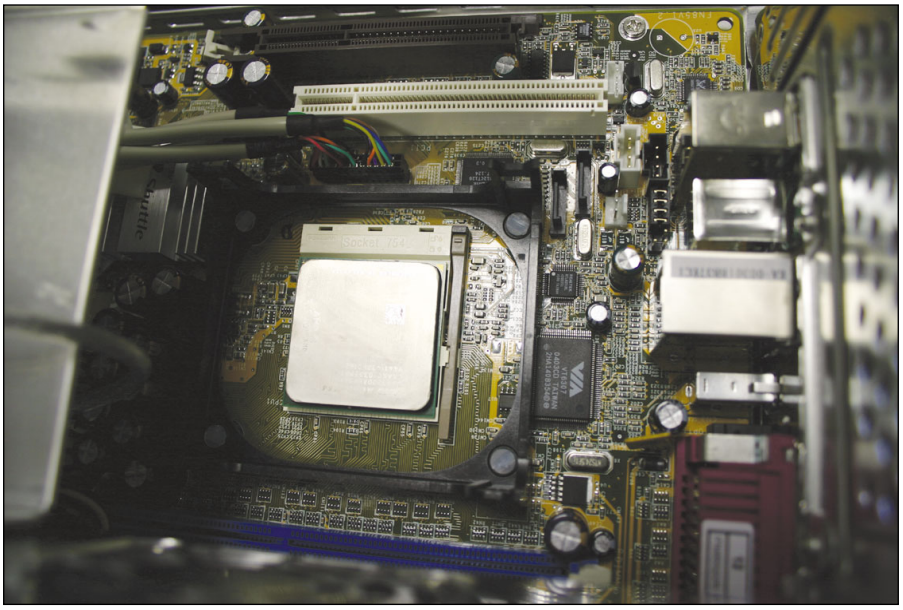
Happily, only five minutes later we received a response that cleared up a major misunderstanding. The tech explained that there were two versions of the 3200+: the Newcastle core and the Clawhammer core. We had the Clawhammer core, with a true speed of 2GHz, meaning our CPU speed required no tweaking whatsoever—served us right for pinching other writers' components to build our own system.

With all of our drivers updated, there was nothing left to do but take our system for a test drive. We installed PCMark04 and 3DMark03 to see how our little beauty would withstand the punishment of these benchmark applications. After the dust settled, our final PCMark04 score was 3773. Our 3DMark03 score was even better, weighing in at 5587.

Watch Out

Many small-form-factor motherboards don't include an integrated video-output port; ours certainly didn't. That means you have to install a video card if you expect to use your new PC, and while you don't have to buy a pro-caliber card like we did, a more expensive card will add a lot of longevity to your PC's graphics capabilities. ▲

These four screws might be mounted externally, but you have to remove them to take out the CPU cooling assembly.



Be sure to lock down your CPU after you drop it into its socket.

Final Remarks

Our inexpensive and small PC proved to us that you don't have to spend a lot of money or invest in huge, server-type parts to create a computer worth keeping for several years. The PC we built had enough punch to smoothly execute games that bogged down other fairly new machines in our office.

But best of all, our little powerhouse was small enough to carry from place to place without being a lead-like burden. That brings up one of the components we wished we would've ordered for our computer—a handle. Many modding retail sites offer anodized case handles in a variety of colors for less than $20. Drill a couple of small holes in the top of a case and screw the handle into place, and suddenly, your small computer is not only light but also easy to tote to the next LAN party.

We also would've liked a computer with more than two USB ports. Fortunately, adding more ports is easy to do with an inexpensive port hub or with ports mounted to the rear of an appropriate PCI card.

Armed with this information, you can see that it's not difficult to gather and assemble parts for a small-form-factor PC that has enough processing power to last for years. Take your time and find the parts you like best, and you'll have a transportable PC that will make you the envy of every regular desktop grunt you meet. RS

by Nathan Chandler

SMALLEST WINXP MACHINE UNDER $1,500

Build A Full-Power Mini PC On A Tiny Budget

Build #28 Skill Level: 1 **2** 3 4 5 ***Apprentice***

You've seen servers that sprawl across acres of office space. And you know just how big those ridiculous Pentium II-era cases could be. Now check out a computer that's just a tad smaller—small enough, in fact, to stuff into your backpack for safekeeping.

Goal

Our editors told us to build the smallest Windows XP system possible. But there was just one problem with this mission: It's been done countless times before. Perform a few quick Google searches, and you'll find many examples of hardcore minimalists cutting, gluing, squishing, and squashing parts to make PC components fit into spaces as cramped as a cardboard WinXP box. Clearly, short of re-engineering a few PC components, there was no way to make a computer much smaller.

So instead, we decided not only to make a tiny PC, but a self-contained mini PC with a full-sized PSU integrated into a custom-made case. And we didn't want just any case—we wanted one that any user could build in a couple of hours, on a budget of just a few dollars.

Background

SFF (small-form-factor) PCs are often only one-third or one-half as large as regular desktop PCs. Many such computers incorporate the use of regular hard drives, optical drives, and cooling components that, although convenient and easy to buy, expand their girth and devour precious space.

There are other form factors that forgo conventional PC parts for smaller components that are harder to find and sometimes more difficult to assemble but keep the resulting PC's footprint much tinier. Unfortunately, these systems often use custom-made PSUs with almost no kick. As a result, we selected parts that worked with the Mini-ITX form factor, but we used a regular PSU so we could use a normal range of devices.

We couldn't use all "normal" components, though. This particular form factor is so small that many of its parts lack flexibility and adaptability. Some motherboards, for instance, come with their CPUs soldered into place, meaning there's no way to upgrade a processor or even swap out an accidentally fried chip.

Given our penchant for destroying various pieces of electronic equipment, we decided to find a Mini-ITX motherboard that would let us substitute CPUs whenever necessary. We went with a VIA EPIA P4 ITX motherboard that would let us use a fast processor—a 3.06GHz Pentium 4—and up to 1GB of RAM.

In the past, we've seen Pentium 4s edge perilously close to heat-induced death because of inferior heatsinks or heatsink fans with too little oomph. That didn't stop us from buying a low-profile heatsink for our CPU.

There was no need for us to spend any cash on a video card, as our VIA motherboard came with onboard video capabilities. The S3 ProSavage8 chip came with AGP 4X and offered S-Video and TV-Out ports for extra multimedia features. To fill in RAM slot, we went with 512MB of RAM and then spent extra on our primary storage device, a tiny but spacious 60GB Hitachi notebook hard drive.

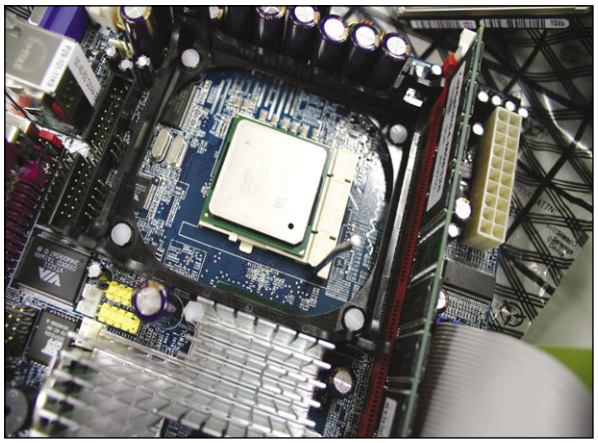
To make sure we could back up critical data, we also needed a rewriteable optical drive. There was no way to squeeze a DVD-RW drive under our budget cap, so we found a CD-RW/DVD combo drive instead.

We couldn't fathom using a clunky keyboard for our super-small PC. At first,

a regular wireless keyboard sounded tempting, but then we found an 88-key mini wireless keyboard with a 23-foot transmission range for only $50. That deal was too good to pass up.

We opted to use an in-house mouse, but for users who really want to give the impression of a super-small PC, there's no point in using a regular old optical mouse. The Targus Ultra Mini Retractable Optical USB mouse is a much better choice. This mouse's name says it all—it's super small, it doesn't use an old-fashioned ball that would attract gunk, and its cable is easy to manage, making the mouse more portable and more discreet than regular optical mice.

Because we already had plenty of monitors in house, we opted not to buy one for this machine, but we did leave cash in our budget for something appropriate. Because we obviously wanted a space-conscious monitor, we figured an LCD would best fill the bill. We had zero desire to invest in a small, 15-inch screen from a no-name manufacturer, though, so we budgeted for a 17-inch Sony SDM-S73, a high-quality monitor that was selling for about $450 at the time of this writing.



We dropped our CPU into its socket after we made sure that its arrow was pointed at the locking lever.

And finally, we needed smooth, consistent power for our fast CPU. For this job, we picked up a 300-watt Antec PSU.

The Build

Observant readers will notice that we didn't mention a case in the parts section of this article. That's because we didn't buy a case.

We thought about modifying our motherboard and other components to squish and smash various parts into a tiny box prone to high heat levels, but as we mentioned, this has been done many times before. To make things more original, we decided to make our own mini case as cheaply as possibly, and better yet, provide enough room for a standard PSU, which would greatly expand the possibilities for our little guy.

To that end, we went to our local superstore and rummaged around in the home and office supplies aisles until we found exactly what we were looking for—a $3 Sterilite container (model 1894) with clear sides and a clip-on top complete with a convenient handle. This container had just enough internal space for our motherboard and a PSU.

With our new case firmly in hand, we gathered together a few necessary tools, including a drill, Dremel tool with a head designed for making straight cuts, as well as a few random standoffs, screws, drive bay rails from a standard ATX case, and a mini bungee cord. Confused yet? Don't worry, at first, so were we.

Our first task was to affix the motherboard to the inside of our case in a manner that would prevent our hot CPU from melting a nice hole in the bottom. There was a minor problem of keeping the board level because of a curved ridge that ran around the edge of the container's interior. By using standoffs stacked on top of one another, we managed to create an appropriate level of clearance and also keep the mobo from tilting too much to one side.

Before we drilled holes for the standoffs, though, we used our Dremel tool to make a rectangular opening for our motherboard's port plate. The Sterilite's plastic didn't offer much resistance to our efforts. We popped the plate into place, drilled holes for our standoffs, and screwed the motherboard down tightly.

Our next task was to find a way to keep the PSU stationary inside the case. Although the PSU did fit in the case when rested at the bottom of the case next to the motherboard, we decided to elevate the PSU so that its fan would fit firmly against what we designated as the case's rear. This setup made sure that hot air generated by the PSU would immediately exit the case.

Keeping the PSU secure was a simple matter of using four screws through the Sterilite container's plastic, which we

System Notes	
Height	7 inches
Width	9.5 inches
Depth	12 inches
Weight	7.3 lbs
Features	
60GB Hitachi Hard Drive (7,200rpm)	
3.06GHz Pentium 4 OEM CPU	
1 PCI Slot	
Integrated S3 ProSavage8 AGP4X Graphics with S-Video and TV-Out	
VIA VT1616 6 Channel AC'97 Codec	
VIA VT6103 10/100 Base-T Ethernet	
Two USB 2.0 Ports (2 pin-header for four additional external USB ports)	
One Floppy Disk Drive Port	
Benchmarks	
3DMark03 Score	653
SiSoftware Sandra	
CPU Multimedia benchmark	
Integer x8 iSSE2	23614
Floating-Point x4 iSSE2	32942
Hard Drive File System Benchmark	29
Memory Bandwidth Benchmark	
Int Buffered iSSE2	1336
Float Buffered iSSE2	1336
CPU Arithmetic Benchmark	
Dhrystone ALU	9408
Whetstone FPU/iSSE2	3847 /6839
Cache & Memory Benchmark	
Combined Index	5242

Watch Out

Spray painting a plastic case is fun, and there are plenty of methods you can use to create different effects, but be sure you select a paint that's designed for plastic–otherwise your artistry will run onto the drop sheet. ▲

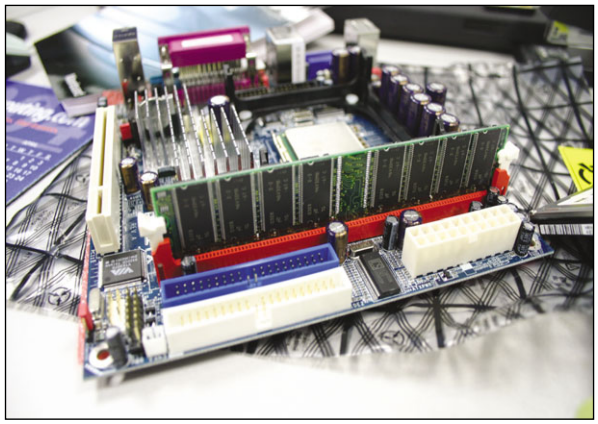
found was rigid and thick enough to support the device's weight. Once we confirmed that four screws would do the trick, we removed the PSU and used the Dremel tool to cut holes for the PSU's cable connector and power button. We also cut slits so that the case wouldn't block the PSU's air flow, and to make sure it fit snugly over the PSU, we trimmed a little plastic from the case's lid.

Then it was time to install our two drives. The hard drive was easy. We screwed standoffs to the bottom of the drive, and to make use of the gap under our PSU, we drilled holes and affixed the drive there.

Our optical drive was more difficult to install, for obvious reasons. We had to create a slit so that the drive's tray could open and close, and we needed a bracket of some sort to keep the drive in a precise position. That was when we decided to jury-rig a bracket using our two drive bay rails.

To do so, we bent the metal tabs on the end of each rail at a 90-degree angle. We screwed the plastic ends of the rails together at a right angle, creating a nice L-shaped bracket that we slipped into the case and secured to two sides of the case.

This created a sturdy platform for our combo drive, but because this slim drive didn't have any screw holes on its bottom or top plates, we again had to improvise during the installation. Because the case had a viselike grip on the front of the drive, we needed something more to make sure the drive didn't bounce around during road trips. We found our solution with a mini bungee cord that wrapped around the drive and our L-shaped bracket. The drive stayed put even when we jostled the case.



Our RAM module went into the red slot next to the CPU socket.

With all of these preparations complete, we realized our PC had no power button. We stole a power button from an old case to resolve this problem.

From the ground up. Once we confirmed that each and every part would fit safely in our case, it was time to remove our drives, install the CPU, and make the proper wiring connections.

We started by installing the CPU. To do this, we lifted the CPU socket lever, dropped the CPU into place, and lowered the locking lever to secure the chip.

We pulled the various components from our Spire heatsink's box. This product included a low-profile copper heatsink with fan, two heatsink brackets, and thermal paste. After we applied some thermal grease to the CPU, we lowered the heatsink on top of the CPU. To lock the heatsink's brackets, we looped the rigid end over one of the CPU's socket holes and then pressed down until the floppy side of the bracket reached the opposite side of the socket. We repeated this step for the second bracket, but to keep even pressure on the CPU, we reversed the second bracket. Then we plugged the heatsink's fan into the three-pronged header on the motherboard.

Unlike most motherboards, which often have two or more RAM slots, our Mini-ITX board had only one. We made sure our RAM module was oriented properly, and we snapped it into place next to the CPU socket.

For our hard drive installation, we connected a regular IDE cable to the blue IDE 1 slot on the motherboard. The other end of this data cable went to a special slim hard drive adapter, which then plugged into the back of the drive. A two-wire power connector went to the edge of the hard drive adapter and then to a regular four-prong plug coming from our PSU. Our optical drive needed an IDE cable, too, so we plugged one end of a cable to the back of our drive's adapter and the other end to the white IDE 2 slot on the motherboard. The PSU's floppy drive power cable went to the underside of the optical drive.

Then we connected our monitor and mouse to the motherboard. We decided to use a standard keyboard instead of our wireless version during the test run, so this

Parts List

Component	Model	Price
Case	Sterilite Container (model 1894)	$3
Motherboard	VIA EPIA P4-ITX Motherboard	$185
Processor	Pentium 4 3.06GHz (533MHz) OEM	$208
Memory	Ultra 512MB PC2700 DDR RAM	$95
Hard Drives	Hitachi 60GB 7,200rpm Notebook Hard Drive	$208
Optical Drive	Black Slim CD-RW/DVD Combo With Adapter	$119
Monitor	Sony 17-inch LCD Monitor (SDM-S73)	$445
Power Supply	Antec 300W PSU	$39
Heatsink	Spire RackSper III Low-Profile Copper Heatsink	$13
Mouse	Targus Silver Ultra Mini Retractable Optical USB Mouse	$22
Keyboard	Fentek Wireless Keyboard	$50
Operating System	Windows XP Home Edition	$90
Miscellaneous	Drive Bay Rails, Spray Paint, Power Button	$10
Total:		**$1,487**

Time-saver

If you decide, as we did, to make your own case, premeasure each component before you choose a container. It's fun to improvise mounting brackets, and it's easy to move parts around for the best fit, but you can't conjure more volume for parts that are bigger than you first thought. ▲

keyboard plugged into the purple PS/2 slot. Then we plugged the PSU's 20-pin and 4-pin connectors into their respective spots.

Testing

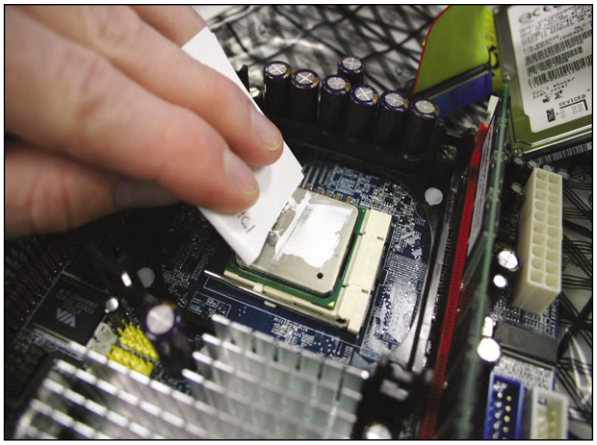
After we double-checked all of our data and power cable connections, we started up our PC. The computer booted to an error message, so we inserted the WinXP disc into our optical drive, and the OS installation began automatically.

We accepted the end-user license agreement and then opted to set up WinXP on our hard drive. On the next page of the setup process, we selected Format The Partition Using The NTFS File System (Quick) to save some time during the formatting procedure. Our drive was formatted in about a minute, and then WinXP began copying files to its installation folders.

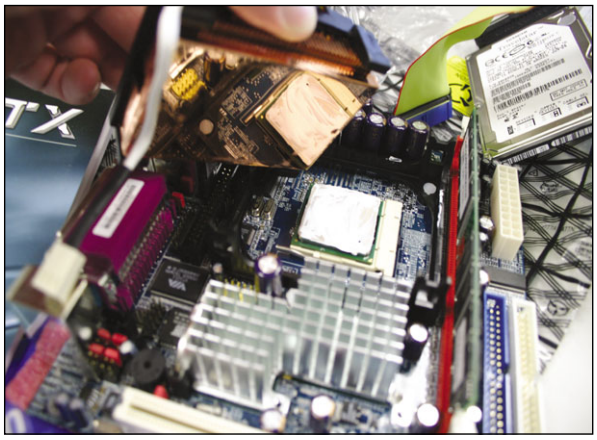
As WinXP continued installing its files, we answered a few basic installation questions. Then the computer restarted and loaded the Windows Desktop. We accessed the Control Panel and then the Device Manager and found two yellow exclamation points that indicated driver problems.

To resolve these problems, we inserted the motherboard's driver disc and then exited the menu that automatically loaded. In Device Manager, we right-clicked the first device with an exclamation point and then clicked Update Driver. We clicked Next to have WinXP automatically find the correct driver. The OS found a usable driver and installed it without further prompts. We then repeated this process for the second exclamation point, and our system was ready to go.

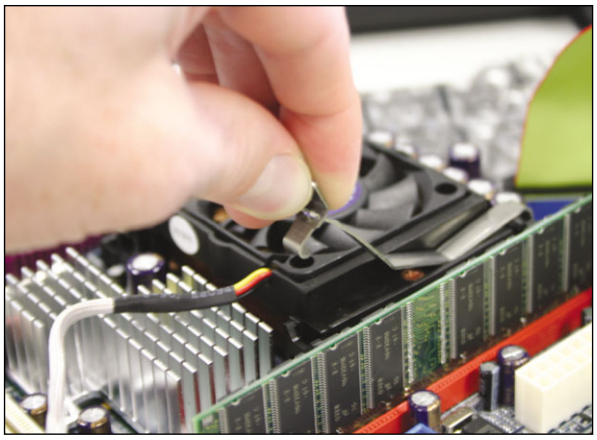
Well, almost ready to go. First, we had to get our mini wireless keyboard up and running. We turned off our computer and connected the keyboard's receiver to a PS/2 port on our motherboard. When we restarted the computer, the receiver's power light came on, but for some reason, this device wasn't seeing a signal from the keyboard. We shut the computer off again and pulled the tabs off the DIP switch covers on the receiver and the keyboard. Using a tiny screwdriver, we set the DIP switches on both devices so that switches 1 and 4 were set to On, and switches 2 and 3 were set to Off. After we restarted the computer, our mini keyboard worked.



A dab will do ya—we smeared an even layer of thermal grease on our CPU to prevent heat buildup.



The low profile heatsink slipped neatly into our motherboard's Pentium 4 socket. Nice and easy.



These simple retainers looped over our heatsink and onto our socket's standard Pentium 4 bracket.

We loaded PCMark04 and ran each of its tests to see how well our machine would perform. During the graphics tests, the benchmark program slowed nearly to a halt, so we knew that our final score would be dragged down by our onboard video chip. The final graphics score was only 244, but our overall PCMark score was a solid 2,855.

Final Remarks

Although our machine wasn't fit for high-tech games, it was obviously plenty fast for most office applications, proving that you don't need a big computer to do big jobs. In hindsight, we would've changed a few things about our machine.

First, we would've moved our optical drive bracket so that it extended from the side of the case, rather than the front. This change would free up the PCI card slot for users who need more functions. Second, we would have used a different paint for the case's exterior. Special plastics paint wouldn't have left the splotchy marks we ended up with. And third, a changeup in our component lineup would've made it possible to install 1GB of RAM instead of 512MB.

Though at first we were doubtful about the power of such a tiny PC, we were happy with the results, and we're certain that other PC builders will enjoy similar tasks, so long as they're willing to improvise. Mini-ITX is here to stay—build your own and customize as your imagination sees fit. RS

by Nathan Chandler

Thinnest Form-Factor PC Under $1,500

A Slim-Fast Computer Plan

Build #29 Skill Level: 1 **2** 3 4 5 *Apprentice*

Most of the computers in this issue are impressive beasts, designed to provide speed and power. However, many of these systems are also very large. For this project, we decided to take a different approach and build the thinnest system we could. Once fairly rare, Mini-ITX motherboards and cases are easier to find today, so the only question was how thin is in. Take a look.

Goal

Our mission was to build the thinnest computer for less than $1,500. We were surprised to learn how relatively affordable it is to build a super-thin system. If you leave out some of the peripheral devices we used, you could build a very slim computer for substantially less than $1,500.

Before we started shopping for parts, we decided upon a few guidelines for this system. Our goal was to create the thinnest system possible. Therefore, given the option between a top-performing system that was relatively thin and a more sluggish system that was extremely thin, we would select the latter. Although our goal was to consume as little shelf space as possible, we recognize that you may be willing to add a few centimeters to your PC's size in order to accommodate more features and better performance. Therefore, you should keep in mind that a different Mini-ITX system or a Micro-ATX system, although not as slender as our PC, may be better for you if it offers beefed-up performance.

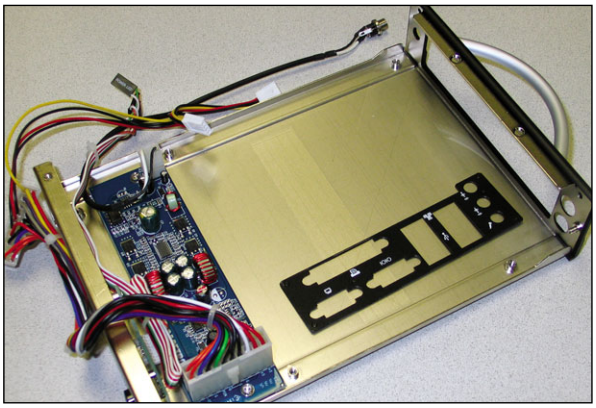
Background

We did not realize exactly how thin PCs could be until we started shopping. We limited our search to cases that conform to the Mini-ITX form factor. Mini-ITX cases are the smallest you will find. Previously, the smallest systems were built on either the Micro-ATX or Flex-ATX form factors. Mini-ITX is even smaller and dictates that motherboards shall not be larger than 170 x 170mm.

We found several Mini-ITX cases that were less than 3 inches thick. Most were either Travla Casetronic (www.travla.com) or Morex cases (www.procase.com.tw). We liked some of the Morex cases, but the thinnest ones were 2.5 inches thick, and we could find thinner systems in the Casetronic line. We bought the thinnest case we saw, a 2-inch-thick Casetronic C150. This system is so thin that you can actually mount it in a car stereo bay.

We chose to pair the C150 case with VIA's EPIA CL-6000 motherboard, which has dual LAN and four Hi-Speed USB 2.0 ports. We selected this motherboard because of its dual LAN. We saw potential in placing this tiny PC on the shelf of an entertainment center and using it as a music server in the future. With dual LAN, we would be able to send music to more than one stereo system. You may never wish to use your Mini-ITX system in such a way, so you may wish to choose a board with better graphics capabilities, a faster processor, or FireWire ports instead.

VIA solders its processors onto its EPIA Mini-ITX motherboards, so we did not have to choose a processor. VIA made the decision for us; our CL-6000 board came with a VIA 600MHz C3 CPU. You may be shocked to see that our system has only a 600MHz processor, but keep in mind that Mini-ITX systems are not built for demanding applications or games. Instead, these systems are designed to run cool, consume little power, and perform basic computing tasks, such as word processing and



Here, you can see the open case before we installed the rather small motherboard. Small is good.

Web browsing. In fact, our system had a 60W power supply. In comparison, our Intel P4 systems had 350W or better power supplies. Mini-ITX is simply not as demanding. If you want to build a small PC that would make a good gaming rig or perform processor-intensive tasks, you should consider building a slightly larger Micro-ATX system rather than a tiny Mini-ITX system.

Mini-ITX computers are small, in part, because many system components are built into the motherboard. For instance, video, sound and network card functionality are all incorporated into the CL-6000 board.

We also purchased 512MB of low-profile DDR SDRAM. We chose low-profile memory so that it would fit in the very thin C150 case. Similarly, we had to buy a notebook hard drive and a notebook DVD drive to accommodate the slender design of our system. We selected a 60GB 4,200rpm drive. Shortly after we ordered parts, prices came down further, making it possible to buy an 80GB drive for only $22 more than what we spent for our 60GB drive. If we had it to do over again, we would splurge for the 80GB drive. We got a good deal on a notebook DVD/CD-RW drive by ordering it from the same place we bought the case and motherboard. We bought the best drive they had, which was an 8X DVD/24X/8X/24X CD-RW slim combo drive.

All we had left to order was our peripheral devices. We started with a Samsung 173S 17-inch LCD. This monitor was a nice match for our C150 case. The LCD design provided us with a 17-inch display yet ensured that the monitor wouldn't consume more space than necessary (or hide our view of the tiny C150 case). The monitor was also black and complemented the black C150 case nicely. More importantly, it offered a 450:1 contrast ratio.

Because one of the areas in which this otherwise modest Mini-ITX system excels is as a media system, we added a set of Altec Lansing 221 2.1-channel speakers and a Logitech diNovo Media Desktop to our system. Of course, you can skip the speakers and the rather pricy keyboard and build your Mini-ITX system quite affordably.

The Build

We looked forward to building this system because it was so unlike any other system we've built before. We anticipated some challenges in building this computer because the motherboard and other components are smaller than most and because we needed to install them in such a tiny case. We were surprised to discover, though, that setting up a Mini-ITX form factor system was relatively simple.

Open the case. One of the first things we noticed about the Casetronic C150 was that it has a built-in handle on the back of the case. We assumed that the handle was for transporting the tiny system easily. However, as soon as we started building the system we learned the true rationale behind including the handle. It is an essential piece in opening the case. To open the case, you first unscrew the two large thumbscrews on the back of the case. Then grasp the handle firmly in one hand and the front of the case with the other hand. There is even a small groove built into the top of the case to help you get a good grip. Then just pull on the handle to slide the case open. Don't be afraid to use a little bit of force if needed. We found that the Casetronic C150's construction was very sturdy.

Next, we used a Philips screwdriver to remove the screws that secured a large metal plate over the inside of the case. We set the metal plate to one side and turned our attention to the bottom piece of the case.

Install the motherboard. When we tried to set the motherboard in the case, we found that the power cable was in the way. We used a pair of small pliers to get a grip on the nut on the back of the case and loosen it enough that we could twist it off. Then we pulled the cable out of the way.

A small backplane for the ports comes with the case. We held this against the large opening on the inside of the back of the case. We then threaded the ports of the motherboard through the holes in the backplane and gently lowered the motherboard into the case. We used a Phillips screwdriver and the supplied screws to attach the motherboard to the case. Then we simply threaded the power cable back through the proper

System Notes	
Height	2 inches
Width	7 inches
Depth	10 inches
Weight	4.66 lbs.
Feature Set	
System Highlights: Only 2 inches thick, with low-profile DDR SDRAM, four Hi-Speed USB 2.0 ports, dual LAN, DVD/CD-RW combo drive, and quiet operation	
Peripheral Highlights: 17-inch LCD with a 450:1 contrast ratio, Bluetooth keyboard and mouse (with Bluetooth adapter), keyboard includes built-in remote control for navigating media, remote includes LCD with email and other alerts	
Software Highlights: Windows XP Home	
Performance	
3DMark03	2
PCMark04	374
Summary	
An extremely thin system (just 2 inches thick) that includes dual LAN and four Hi-Speed USB ports. Keep in mind, though, that this system is for basic computing and not for CPU-intensive work or for gaming. If you don't believe VIA when it says its EPIA system is not built for gaming, check out our wimpy 3DMark03 score.	

opening on the back of the case and screwed the retaining nut back on to secure the power cable in place.

Connect the power supply. The power supply for the C150 case is located on a built-in PCB. This board is secured to the inside of the front of the case. It was easy to locate the PSU because a large bundle of power cables was attached to this area of the case. We found and connected the small, labeled cables for the power LED (POWER LED), power switch (POWER SW), hard drive LED (HDD LED), and reset switch (RESET SW). The proper jumpers were labeled on the motherboard, as well as in the motherboard manual.

Next, we supplied power to the motherboard itself by locating the largest of the power cables and connecting it as indicated in VIA's manual. We wiggled the connector just a bit to ensure that its plastic clip clamped over the clip built into the motherboard, locking the power cable in place.

Add RAM. Next, we inserted the low-profile memory we'd bought. If you know how to install memory modules in a full-sized system, you know how to install memory on a VIA EPIA motherboard. The only difference is that you may need to buy low-profile memory to ensure that it fits in even the smallest of systems.

We pressed the small levers on each side of the DIMM slot to move them to the unlocked position. Next, we lined the memory module up with the DIMM slot and gently but firmly pressed on the memory until it dropped into the slot. We knew the memory was secure and properly installed because the levers on each side of the RAM snapped back up, locking the memory in place. Once the memory was installed, we had placed all components on the motherboard. We were ready to attach the remaining devices to the metal plate.

Install components on the metal plate. Our notebook-style DVD drive slid easily into a thin bay on the metal plate. We screwed the drive into place through small holes on the side of the bay. Next, we held the hard drive against the metal plate, positioned so that the pins on the drive faced the edge of the plate. We screwed the drive in place using the six provided screws. We then connected the fan in the same way, positioning it directly under the round fan opening in the metal plate.

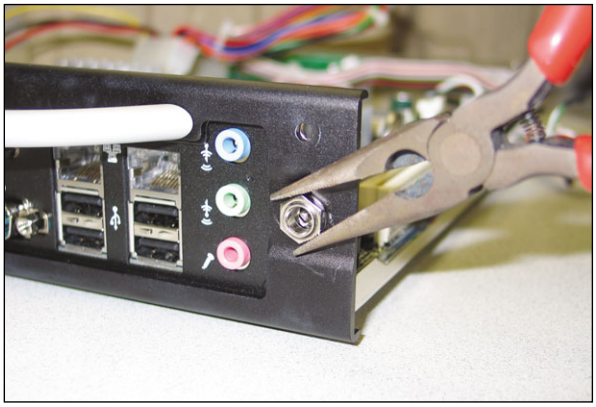
Connect power and IDE cables. Next, we connected the parts on the metal plate to the power supply and motherboard. We started with the hard drive by connecting an IDE cable (which came with the motherboard) to the hard drive at one end and to the indicated position on the motherboard, which in the case of our VIA CL6000 board, was next to the DIMM slot. One end of the IDE cable had a small set of wires to power a connected device. This end of the cable attaches to the drive, and the other end plugged into the motherboard. Next, we connected the set of power wires to one of the power supply's small cables. The two connecting ends snapped together easily.

We followed the same procedure to form data and power connections for the DVD drive. First, we connected the IDE cable to both the motherboard and the drive. Then we connected the power supply to the DVD drive by attaching one of the power supply's cables.

Finally, we located the fan jumpers on the motherboard and attached the fan's connected wires to the motherboard. Because space inside the Mini-ITX case is limited, the cords are short and barely stretch between the case and the metal plate. We had to prop the metal plate up at a 90-degree angle to the case in order to attach all of the cables.

Attach the metal plate. It was already time to reassemble the case. We started by screwing the metal plate to the small ledge at the back end of the case. This will suspend the metal plate over the motherboard, with the DVD drive, hard drive, and fan hanging over the motherboard.

Be careful and make sure you connect the metal plate correctly. We learned the hard way that there is only one way this piece fits, and if you attach it the wrong way, you could have a very tricky situation. Make sure the plate is positioned underneath the metal ledge at the back of the PC. If you screw the plate on over this ledge (or lip), the case will likely get jammed, half open and half shut. You do not want to make this mistake. It took one 5-foot 3-inch woman, one 6-foot 1-inch man, one 6-foot 4-inch man, and over an hour of effort to pry our case open again. You will note, however, that our system is no worse for the wear and that the handle stayed attached to the back end of the case. The Casetronic C150 is one well-designed sturdy little case to withstand such abuse.



If it is difficult to insert the motherboard, you may need to remove the power cable temporarily. We used a pair of pliers to loosen the retaining nut on the back of the case.

Reassemble the case. It was simple to reassemble the case (once the metal plate was connected properly). We slid the cover back over the bottom half of the case and pushed it shut and then inserted and tightened the two thumbscrews on the sides of the back of the case.

Connect the peripheral devices. Once the computer was built, we connected the monitor cable to the port on the back of our tiny PC and tightened its screws. Next, we connected the keyboard and mouse to the proper ports on the back of the case. Because our system would not

have USB support until after we installed Windows, we needed to initially connect our keyboard to the PS/2 keyboard port using the provided PS/2 adapter. We also plugged our mouse into the back of the system, using a PS/2 adapter for the mouse, as well, so that the system would recognize the mouse before we installed Windows. As is the case with most modern systems, the keyboard port was color-coded purple, and the mouse port was color-coded green, making it simple to plug peripherals into the correct ports. We did not plug our speakers into the system yet. We would do that later, after we had installed Windows.

Start the PC and install software. At last, we were almost ready to start our system. We connected the power cables for the computer and monitor and then plugged them into our surge protector. Finally, the basic skeleton of our system was built, and we were ready to install Windows. We started the computer and turned on the monitor. When the machine started to boot, we pressed the Eject button on the DVD/CD-RW drive and inserted our Windows XP Home Edition installation disc. We followed the instructions on the CD to install Windows. We also ran the VIA mainboard installation disc that came with the CL-6000. Finally, we entered Windows' Control Panel to adjust the refresh rate of our monitor to reduce some flickering.

Testing

When we started our computer, Windows automatically set the screen resolution at 1,024 x 768 pixels. We liked the way the display looked at this setting. However, if we had wanted to make changes, we could have done so through Windows' Control Panel. We didn't encounter any problems, so we ran a pair of benchmarks to test our tiny PC.

Parts List

Component	Model	Price	Notes
Case	Casetronic C150	$396	
Power Supply	60W power supply	$0	Included with case
Motherboard	VIA EPIA CL-6000	$5	Included with case as $5 upgrade
Processor	VIA 600MHz C3	$0	Included with motherboard
Memory	512MB low-profile DDR SDRAM	$121	An add-on with case purchase
Hard Drive	60GB notebook-style 4,200rpm drive	$153	An add-on with case purchase
Video Card	Built into motherboard. (Integrated VIA Unichrome graphics)	$0	
Sound Card	Built into motherboard. (VIA VT1612A)	$0	
Network Card	Built into motherboard. (VIA VT6103 10/100 Base-T 10/100 Fast Ethernet Controller)	$0	
CD Drive	See below	$0	
DVD/CD-RW Drive	Slim notebook-style 8X DVD/24X/8X/24X CD-RW Combo Drive with adapter	$119	An add-on with case purchase
Monitor	Samsung 173S 17-inch LCD	$369	Dads & Grads Special
Speakers	Altec Lansing 221 2.1 speaker system	$40	
Keyboard	Logitech diNovo Media Desktop	$199	
Mouse	Included with keyboard.	$0	
OS	Windows XP Home	$89	On sale; clearing out SP1 before SP2 release
Total		**$1,491**	

3DMark03. The first benchmark we ran on our system was 3DMark03. This told us one thing clearly: VIA was not kidding when it said its EPIA components were not designed for gaming use. In fact, 3DMark03 could only run one of the four game tests. The test it ran produced a spectacularly low score of just 2 3DMarks. Further analysis of the results showed that our Mini-ITX system performed at only 0.3fps. The only other two tests that 3Mark03 could run were Single-Texturing Fill Rate and the Multi-Texturing Fill Rate, which the software recorded at 94.3 MTps (megatexels) per second and 125.8 MTps per second, respectively. We knew before we ran these benchmarks, though, that our system would fail miserably at any gaming test because we didn't build the system to excel in these areas.

PCMark04. We hoped for more respectable scores with PCMark04. The overall score was 374 PCMarks, which was far from ideal. A breakdown of PCMark04's individual tests revealed the Mini-ITX system's strengths and weaknesses. Our system scored very low on all tests except for the hard drive tests, on which the PC performed admirably, returning moderate scores. This is exactly what we expected from this system: decent scores in areas for which it was designed, such as Windows XP Startup and Application Loading, but very low scores in graphics applications.

Final Remarks

We were very pleased with the size of system we built. Even though we'd noted the specs before we ordered the case, we were still shocked when we saw how small our system really was. For basic computing tasks, our computer did a decent job. However, if you want to build a system with more power, you should plan to reserve a little bit of extra room on your desktop and build a bigger system. If size and cool operation is important to you, however, you can't beat a Mini-ITX system's efficient use of space and cooling. RS

by Kylee Dickey

Quietest System Under $1,500

Dampen The Din With Super Quiet Products

Build #30 Skill Level: 1 **2** 3 4 5 *Apprentice*

You let your computer's quirky assortment of technological gobbledygook sounds drive you completely nuts. You allow its incessant drone to invade your sleep and cause noise-induced nightmares. Nevermore. It is time to quiet the beast before insanity sets in.

Goal

As PCs get faster, they tend to get noisier, and for those of you with a hankering for peace and quiet, excessive noise is an aggravation that impedes productivity. Parts makers feel your pain, and they want to profit from your headaches by soothing all that exasperation away. It's because of these cutting-edge, so-called "quiet" PC components that we decided to build a nearly silent PC for under $1,500.

Background

We opted for a standard-speed system like you'd find in many homes, including a powerful but cost-effective Pentium 4 2.8GHz CPU paired with a SOYO Dragon 2 P4I865PE Plus motherboard. These products actually came in a nice bundle from our friends at TigerDirect (meaning there was a standard CPU fan and heatsink included). That clamorous fan, as you will soon see, bit the big one during our shopping spree.

Currently, the 2.8GHz version is slightly slower than the average Pentium you'll see in power PCs at computer retailers, but as of press time, this chip offered superior performance at a reasonable price. Plus, with the silent products we add to our system, this CPU will have plenty of overclocking potential.

A case for quiet. But before we outline our electronics components list, we'll tell you how we planned to use case characteristics to soften our PC's screams. We started by splurging on a nice case: A steel Chenming 601, strong and thick enough to prop up our Maxima for an oil change.

No unmodified case is truly built for quiet operation, though, which is why we opted to buy a NoiseControl Magic Fleece kit that's designed to fit the nooks and crannies of our Chenming case. "Magic Fleece" is essentially "insulating foam," and the real magic here is that you can install the pieces without having to cut and paste messy insulation for four hours.

But why stop with a custom insulation kit? We also bought FrozenCPU's Paxmate Noise Dampening Material to help fill in any spots that the Magic Fleece kit missed. All of this insulation, of course, meant that our system was likely to get at least a bit hotter than the average desktop PC.

Stifling the fans. Our stuffy case definitely needed adequate cooling to prevent our mobo from going to a nice, fluffy, Magic Fleece bed, only to never awaken again because it burned up from excess heat during the night. We started with case fans.

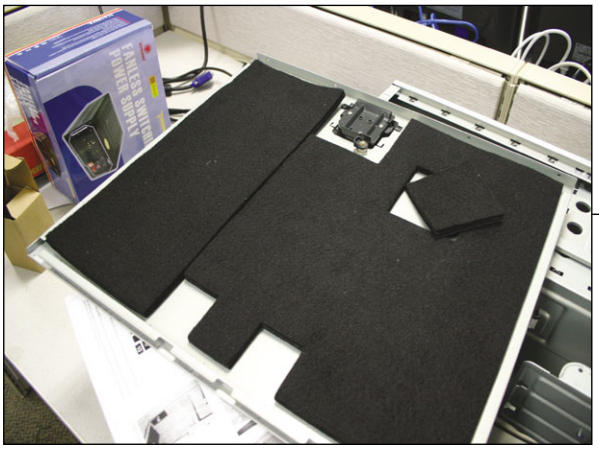
We settled on two 80mm Panaflo Ultra Quiet fans, which are designed to push about 24 cubic feet of air per minute but create noise levels that max out at 21dB, far quieter than average case fans that run at 30dB and louder. To make these fans quieter still, we bought 80mm fan cushions. These springy cushions are made from inexpensive silica gel and have one primary objective, which is to reduce or eliminate the transfer of fan motor vibration to a metal case, where numerous rattles can develop. These cushions are the same size and shape as the fans themselves, and their 2mm-thick profile should be plenty to keep vibration under control.

Of course, fan cushions aren't as effective as they should be if you secure your fans to the case using typical metal screws. Though the cushions offered some protection from vibration, regular screws provide an easy route for fan-motor-generated pulsations to move into your case's other components. Thus, we bought antivibration fan fasteners. These long, skinny rubber fasteners replace your metal screws and secure your fan to the case; paired with the fan cushions you can see why we hoped our fans would produce almost zero noise.

Watch Out

The ends of the Reserator's cooling fins aren't filed down, making for rough, sharp edges. Be careful not to cut yourself when you tighten the hose fittings to the Reserator's base. ▲

Loud power supply fans are often more aggravating than case fans. Fortunately, these days it's easy to locate fanless power supplies. We chose a monster, the 480-watt CoolMax fanless PSU, which creates absolutely no noise but packs enough juice to power many, many silent components.



The Magic Fleece is precut to fit the Chenming 601. For this step it's a good idea to perform a dry run before you start toying with the super-strong adhesive backing.

The only other fan in our case was on the video card, an ASUS V9280 GeForce 4 TI4200. We resolved this problem by investing in a preassembled Zalman ZM80C-HP cooler, which eliminates the need for a cooling fan by cooling the card with a large heatsink and heatpipe system.

Dead-quiet drives. Besides loud case fans, the noisiest parts of a computer are usually the hard drives, which often produce audible grinding and clacking sounds even when they are in brand-new condition. To combat these annoyances, we selected a 160GB Samsung SpinPoint series hard drive, which features SilentSeek and NoiseGuard technology to reduce mechanical noise and vibration.

We decided to take our drive-noise dampening efforts one step further by investing in a Smart Drive 2002 Copper hard drive enclosure. This box is lined with copper plates to absorb heat, and more importantly, reduce noise levels by about 4dB. The enclosure slips into a 5.25-inch drive bay and accepts 3.5-inch hard drives that use either PATA or SATA motherboard connectors.

In spite of our super-quiet product selection, we were worried that our silent system might by spoiled by the moans and groans of a regular optical drive. We weren't worried about buying a drive that could burn a DVD, so instead, we spent extra on a Samsung Noise Reduction combo (52X/24X/52X/16X) drive that rewrites CDs at a good clip and can also read DVDs, but more importantly, includes vibration absorbing materials and an acoustic noise-reduction system.

That wrapped up most of our parts gathering, but we still needed something to replace our CPU fan, and we wanted something that could handle the heat of overclocking. We didn't want to dump our money into a $200 watercooling kit that would obliterate our system's silence with a deafening radiator fan or an incessantly gurgling water pump.

That said, the crown jewel of our silent system isn't a typical watercooling system, it's the Zalman Reserator 1 Fanless Water Cooling System. This phenomenal system includes a 23-inch component that combines a heatsink, water reservoir, and water pump. This snazzy setup looks as cool as it sounds, and it comes complete with a waterblock and a flow indicator so you can confirm that water is rushing along during harsh overclocks. If you want, you can cool both your CPU and a video card chip using the Reserator.

The Reserator is one heavy piece of equipment. It weighs more than 14 pounds, and its height makes the Reserator an unsuitable option if you move your system frequently. However, the device's redeeming quality is that it moves water at 80 gallons per hour, and it does this job silently because there's no radiator fan, depending instead on its massive heatsink fins to dissipate heat from the cooling loop.

The Build

Thanks to the high-quality components we selected, we ran into only a few minor problems during the build process. You can avoid time-sucking missteps, though, by simply reading through our silent system experiences.

One cushy PC. Our first order of business was to use Magic Fleece to insulate the inside of our empty Chenming case. The Magic Fleece comes in a plastic bag stuffed full of square and rectangle foam pieces, all with a plastic backing that you peel off to expose a strong adhesive. Don't start peeling these on a whim because there are a few pieces that should permanently retain their backing.

The instructions for the Magic Fleece consisted of one page of fuzzy diagrams and numbers created by what must've been a copier on its dying breath. Fortunately, it's easy to determine which pieces go where, but make sure you do a test run before you start sticking foam to the case

Parts List	
SOYO Dragon 2 P4I865PE Plus With Intel Pentium 4 2.8GHz 800 FSB (Bundle)	$239
160GB SATA Samsung Spinpoint Quiet Hard Drive	$139
Buffalo Technology 184-Pin 512MB DDR PC-2700	$84
NoiseControl Magic Fleece For Chenming 601	$50
Silver Chenming 601 Steel	$75
FrozenCPU Paxmate Noise Dampening Material	$19
Smart Drive 2002 Copper Cool, Quiet Hard Drive Enclosure	$70
CoolMax 480-watt Fanless Power Supply	$140
ASUS TI-4200 Silent Video Card With Preinstalled Zalman Cooler	$180
Zalman Reserator 1 Fanless Water Cooler	$280
SM-352 Samsung Noise Reduction Combo Drive 52X/24X/52X/16X	$70
Panaflo 80mm Ultra Quiet Case Cooling Fans	$14
Directron TN-PCS80 Shakeproof Washer	$6
Directron Rubber Sticks, Anti-Vibration	$10
15-inch Off-Lease Monitor	$30
Generic Windows AT Keyboard	$7
Beige & Red Color Optical Scrolling PS/2 Mouse	$6
Windows XP Home Edition	$72
Total	**$1,491**

System Notes	
Width	8 inches
Height	20.5 inches
Depth	18.6 inches
Weight	44 lbs
With Reserator	58 lbs
Features	
160GB Hard Drive	
512MB RAM	
Five PCI Slots	
Two High-Speed USB 2.0 Ports	
Two SATA Headers	
AGP 8X/4X	
Benchmark Scores	
PCMark04	3999
3DMark03	1509

because you can't remove these pads without at least partially destroying them.

In a strange twist, we discovered that although the door panel pads were the easiest to apply, they also caused us the most trouble because once we tried to close up the case, the centered padding was too close to the hinge, making it impossible to lock the case latch. We resolved this problem by slicing away slivers of foam using a utility knife.

Fan faux pas. Our next step was to install our Panaflo fans. To make room for all of our special fan-noise-reducing hardware, we had to remove the case's fan brackets. It took some force, but we managed it.

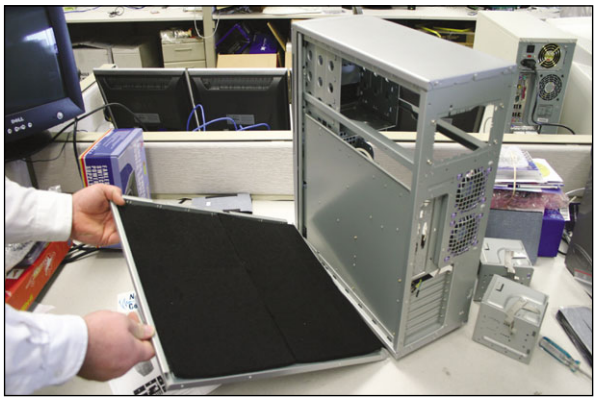
Removing these brackets caused us more problems. The case was specially designed to accommodate the brackets' square fasteners, and the case holes were too large to let us use our vibration-reducing fan fasteners, even after we tried to jury-rig a setup with an extra fan grill (with the right-sized holes) and more foam padding.

We eventually relented and decided to use the original fan brackets. To reduce noise-related problems, we pushed a fan cushion into the bracket and then forced the fan back into the bracket, too. It was a tight fit, but it was secure. Then we inserted thin foam shims between the brackets and the case for a little extra cushioning. Not as comprehensive as our original fan plan, but it did seem to work.

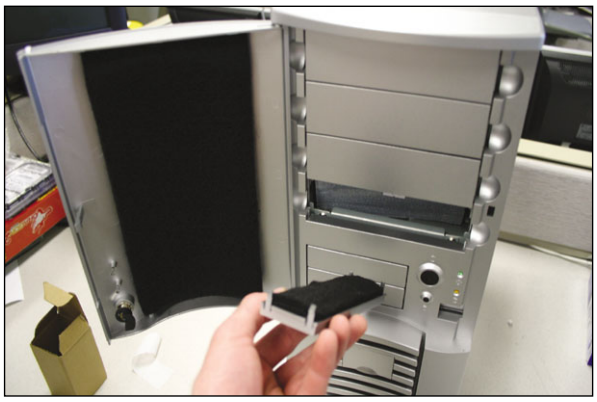
It gets easier. After breaking a sweat with our ill-fated fan plan, we were happy to encounter fewer problems with other components. Because our motherboard ports didn't fit with the case's frame, we pulled a new motherboard plate from our mobo box and tapped it into place. After putting standoffs into their proper locations, it was at long last time to secure the motherboard.

We opened up our SOYO manual for assistance in connecting the Power and Reset switch wires to the motherboard. The manual makes this job easy, and, as with all motherboards, you don't have to worry about making sure the plug is oriented one way or another; just making the connection is enough to make these switches work.

Then we inserted our huge, heatsink-armored video card into the AGP slot. The card slid neatly into place, but if you're looking to load up all of your PCI slots, beware, because the video card will likely block access to the adjacent slot.



Here's an easy step: You'll have to remove the side of your case to complete your padding work.



Even the drive bays and drive bay door are padded, one reason our system made almost no noise.

Watch Out

If you opt for a different motherboard, verify that your model adheres to the 10.2mm rule, which means there's a gap between your socket and other motherboard components, such as capacitors. Otherwise, you might encounter problems when you try to install the Reserator's waterblock. ▲

Reserator is a word. We dropped our CPU into its socket and pulled the Reserator's components from its box. The first step here was to attach the waterblock to the top of the CPU, which was easy enough because we used the Pentium 4's stock bracket to complete the job. Zalman includes an exploded view of the waterblock hardware assembly to help with this task, which took only a minute once we applied a thin later of thermal grease.

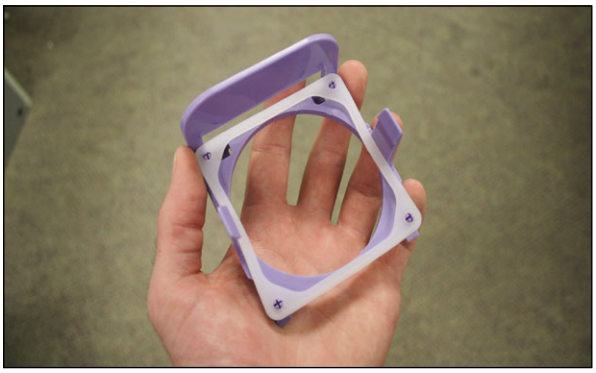
Because the Reserator is so large, it must rest outside the PC case, meaning we had to thread hoses through a PCI card opening on the case. We mounted metal fittings to the inside and outside of the case and then pushed our hoses over the ends and screwed them down securely. We were extra careful when cutting lengths of hose for the inside of the case, making sure they were long enough to easily reach the fittings, but not so long that they caused obstructions.

The Reserator comes with a flow meter to help you judge water flow. For this device to work correctly you must make sure that the orange indicator in the meter dangles from the hose that connects to the Out fitting on the Reserator. If you accidentally set things up backward, no worries, just reverse the hoses and you're ready to go.

Cooler drive. Installing the Smart Drive Cooler wasn't as easy as it should've been. The company included zero instructions for this component, and because the black box was held together by screws on all sides, we weren't sure which

panel to remove to install our hard drive. Eventually, we removed the rear and bottom panels, revealing the shiny copper interior we hoped would lower our too-hot drive's operating temperatures.

We squished the drive securely into place by compressing the thick insulation with our fingers. Before we replaced the panels, we realized that the tiny cable gaps at the back of the Cooler wouldn't be spacious enough for us to wriggle the drive's cables in for a solid connection, so we removed the SATA data cable from the motherboard and plugged it into the drive. Then we retrieved a SATA power pass-through cable and connected it, too. Once we mounted the drive cooler in a 5.25-inch drive bay, we reconnected all cables and fired up our super-quiet masterpiece.



We gave up on our original plan to quiet our fans, but we did force a fan cushion into the case's fan bracket.

Testing

The computer started up correctly and we pressed DELETE to enter the BIOS menu. We selected SOYO Combo Features, Onchip IDE Device, and then changed IDE 1,2/SATA 1,2 to IDE + SATA. We saved our changes and exited the menu.

We lucked out with our SATA drive on this particular system. Because the Windows XP setup routine recognized our hard drive, we didn't have to load a third-party driver for the drive via a floppy disk before we continued the installation. If you use a different SATA hard drive, odds are that you'll have to install a driver manually before you can continue copying Windows files.

We opted to create a single partition on the C: drive and then used the NTFS Quick option to format the drive. The computer restarted and copied Windows files without complications.

After the installation, we inserted our motherboard's driver CD, which automatically loaded a menu displaying motherboard model numbers. In some cases, you might have to double-click the CD Start icon located on the CD to load your installation options. We installed applicable drivers for WinXP and the Hardware Monitor utility.

After we started up our PC and let it run, there was little doubt that it was far quieter than an average desktop machine. However, in spite of our efforts to cushion the case fans, there was no disguising the gentle whir of fan blades emanating from our PC. Directly behind the PC, at the fan grill, we saw a reading of 88dB. When we held the sound meter to the front and sides of the PC case, the readout dropped to about 62dB.

Then we pulled our case fans, restarted the PC, and waited out the POST startup beeps. And then we heard nothing. No matter how we tweaked the settings on our sound meter, our quiet PC's noise levels never breached 10dB, much quieter even than our soft sighs of relief.

We were a little worried by warmer-than-average CPU temperatures. At idle, the CPU hovered near 43 degrees Celsius, which was a little higher than we would've liked to see considering the massive Reserator waterblock and cooling tower. When we started our benchmarking tests, though, we realized our fears were unfounded, as temperatures rose only one degree.

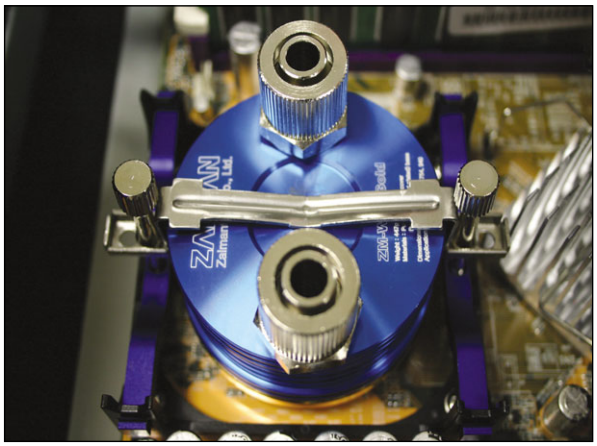
We then tested our PC by running PCMark04 and 3DMark03. After running the system suite and CPU tests in PCMark04, we received a score of 3999. Because we didn't use a high-powered video card, we expected and received a 3DMark03 score of only 1509.

Time-saver

You don't have to let your Reserator consume a PCI slot; Zalman includes instructions for drilling two holes in your case to let the Reserator's hoses pass through without obstructing important motherboard components. ▲

Final Remarks

Although our fan fiasco was frustrating and the Reserator's performance wasn't as impressive as with other watercooling systems we've used, our resulting PC was quieter than a whisper and still cool enough to do plenty of heavy-duty computing. The overall system was very heavy and wouldn't be useful for users who move their systems often, but for those who want peace and quiet, that extra heft is a small price to pay. RS



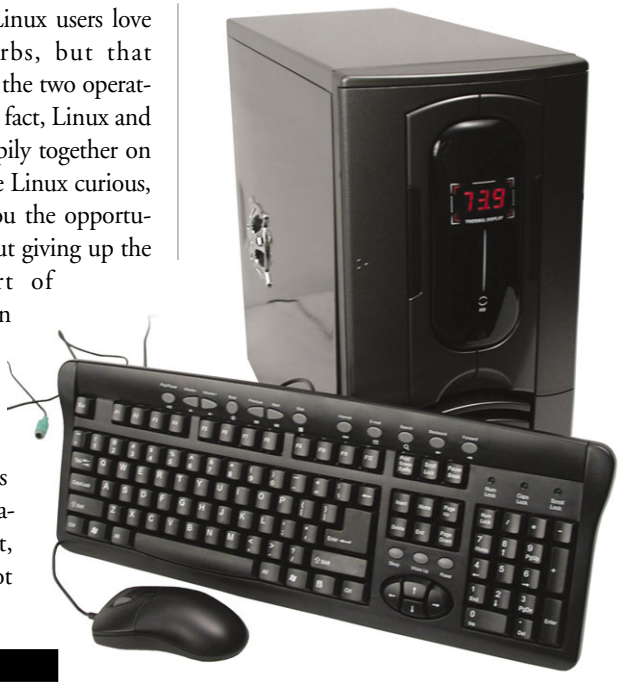
The waterblock is easy to install because it utilizes the stock Pentium 4 bracket. If you use an AMD-brand CPU, you will have extra work to do, but at least you'll be busy.

by Nathan Chandler

Best Dual-Boot System Under $750

Windows & Linux Give You The Best Of Both Worlds

Build #31 Skill Level: 1 2 3 4 5 *Master*



Windows and Linux users love to trade barbs, but that doesn't mean the two operating systems have to fight. In fact, Linux and Windows can live very happily together on the same hard drive. For the Linux curious, a dual-boot system gives you the opportunity to try out Linux without giving up the familiarity and comfort of Windows. Linux lovers can install Windows so they can run popular applications that otherwise don't run on Linux. A dual-boot system makes everyone happy, and it's relatively easy to make. In fact, we put together a dual-boot system for less than $750.

Goal

Our goal was to build a dual-boot system and spend no more than $750 doing so. Our limited budget necessitates low-end components, but if you have a bigger budget you can certainly replace some of our budget-conscious parts with more performance-oriented components. If you do opt to use other components, make sure Linux will support the hardware you choose.

Background

To save some cash, we opted for an AMD Athlon XP 2600+ processor ($85). The Athlon XP is certainly showing its age, but it's cheaper than an Athlon 64 or a Pentium 4. We paired our Athlon XP with an inexpensive ASUS A7V600-X Motherboard ($67). The A7V600-X supports FSB speeds up to 400MHz FSB. Our Barton-based Athlon XP uses a 333MHz FSB, so we opted for 256MB of Mushkin PC2700 DDR SDRAM (PC3200 would be expensive overkill for this system).

The motherboard's Ethernet port and audio codec will save us from having to buy a sound card and Ethernet card. We did, however, need a video card. We settled on an Albatron NVIDIA GeForce FX 5600XT. The card isn't too powerful, but it is cheap at $87, and NVIDIA has excellent Linux support.

We used a Hitachi 80GB SATA hard drive that we found for $74. In order to get Windows XP installed on our SATA hard drive, we needed to load third-party drivers from a floppy, so we spent a little more than $10 on a black floppy drive. We rounded out our storage options with a $30 CD-RW drive.

For the case, we settled on a RAIDMAX Silence 811TP. This case feels every bit as cheap as it is. The sides are flimsy and the design isn't nearly as good as other cases we've seen. At $55, however, we'll take it.

We paired the system with a monitor we had lying around the office. If you don't have a monitor, however, we found a MAG InnoVision 772PFb 17-inch CRT that would've gone well with the system. At $99, the monitor will keep you just under that $750 budget.

Accompanying the system is a Cintre 5.1-channel surround-sound system. Our $10 mouse and keyboard combo helped keep us under that $750 price point. Finally, we had to shell out $87 for Windows XP Home and we downloaded our Linux distribution free of charge.

The Build

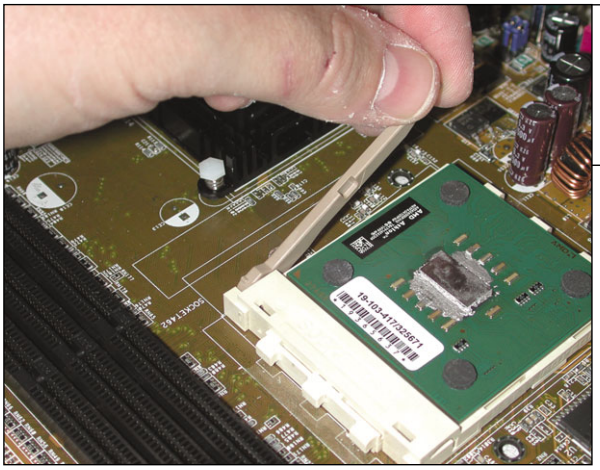
We started the build by prepping the case. Once we had removed both side panels and all the miscellaneous packages and cables, we laid the case on its side and inserted the motherboard to get an idea of where we needed to install standoffs. We set the motherboard aside and screwed the standoffs in place.

Before securing the motherboard to the standoffs, we installed the processor, heatsink, and memory. After dropping the processor into the ZIF socket, we spread a thin layer of thermal paste across the die (the small rectangle in the middle of the processor). We aligned the heatsink so the notch in the heatsink fit with the notch in the socket and placed the rear clamps over the tabs on the bottom of the socket. We used a flathead screwdriver to place the top clamps over the tabs above the socket. After connecting the fan to the header on the motherboard, we installed our memory module into the slot closest to the processor.

With the processor, heatsink, and memory installed, we secured the motherboard to the standoffs using the included screws. Once in place, we began wiring the case to the motherboard. We connected the Power Switch, Reset Switch, HDD LED, and Speaker to the proper front panel pins. (See the motherboard documentation for more information.) We connected the front USB ports to the motherboard's USB headers.

Before we could install our CD-RW and floppy drives, we needed to remove the plastic and metal covers protecting the external 5.25-inch and 3.5-inch drive bays. We used a screwdriver to pop out the uppermost 5.25-inch drive bay. Once we removed the plastic covering from the front of the case, we rotated the inner metal plate until it broke free from the case. We did the same to the uppermost 3.5-inch drive bay.

We slid the CD-RW drive into the top 5.25-inch drive bay and the floppy drive into the top 3.5-inch drive bay. We secured the drives to the case using four screws on each drive. In similar fashion, we secured the hard drive to one of the 3.5-inch internal drive bays.



Insert the processor into the ZIF socket. Press the handle down to lock the processor into place.

Next, we removed the top expansion slot cover on the back of the system by pushing it in and out until it broke free from the system. We inserted the video card into the AGP slot and secured it to the case using a screw.

We used the included IDE, floppy, and SATA cables to connect the DVD burner, floppy drive, and hard drive to the motherboard. Finally, we connected the power supply to the ATX power connector on the motherboard and connected the proper power plugs to the drives and case fans. After sealing up the case, we plugged in the monitor, keyboard, mouse, Ethernet cable, and speaker system.

Windows XP. It's always best to install Windows first in any dual-boot system. Before we installed WinXP, however, we needed to download SATA drivers from ASUS. From the main page (usa.asus.com), we clicked Downloads, selected Motherboards from the Product Menu, and scrolled down to SocketA (462). We selected our A7V600-X motherboard from the list of motherboards and clicked the Drivers at the top of the file list. We downloaded the latest VIARAID drives (VIARAID220d.zip) and unzipped the contents. We inserted a floppy disk into the drive and clicked MakeDisk.exe in the DriverDisk subdirectory.

Once you have the driver disk, you can install WinXP. Press F6 when prompted by the WinXP installer (right after the initial blue install screen first appears). Windows will begin copying drivers and will eventually ask you to load third-party drivers. Press S and insert the floppy disk containing the drivers when prompted. Select VIA Serial ATA RAID Controller (Windows XP) and press ENTER. Press ENTER again to continue with the installation. (Leave the disk in the drive until the system reboots).

When prompted to partition your hard drive, select Free Space and press C to create a new partition. We specified a 35,000MB partition for drive C: and repeated the process to create a second 10,000MB partition. We left the remaining space for our Linux distribution.

Prep. After finishing our WinXP install and installing the necessary hardware drivers, we needed to do a little prep work.

System Notes	
Operating System	Windows XP Home
Processor	Athlon XP 2600+ (Barton)
RAM	256MB PC2700 DDR SDRAM
Bus Speed	333MHz
Hard Drive	80GB SATA
Optical Drive	8X NEC DVD+/-RW
Connectivity	10/100 Ethernet
Video Card	NVIDIA GeForce FX 5600XT
Video RAM	128MB
Monitor	17-inch flat CRT
Sound Card/Speakers	5.1-channel surround sound
Chassis Size (inches)	17 x 8 x 17.8
Weight (pounds)	24.06
Benchmarks	
3DMark03	2767
PCMark04	3121
CPU Score	1952
Memory Score	860
Graphics Score	5088
HDD Score	870

First, we made sure the 10GB partition we created during WinXP installation was formatted as a FAT32 partition by opening My Computer, right-clicking drive D:, and selecting Format. We selected FAT32 for the File System and checked the Quick Format box. Once formatted, we created a directory for each user. We then made sure WinXP used these directories for each user's My Documents directory by right-clicking My Documents in the Start Menu, selecting Properties, clicking Move, and specifying the directory we just created. Repeat this procedure as needed for each user on the system.

You may need to know your monitor's vertical and horizontal refresh rates. If this information isn't included in the product manual, locate it online before you begin installing Linux.

Linux. There are several Linux distributions we could use. Mandrake (www.mandrakelinux.com) is one of our favorite desktop distributions, and it's available for free online. In this instance, however, we opted for Debian (www.debian.org). Debian is famous for its package-management system, which makes it extremely easy to install and remove software (something that can be exceedingly difficult in Linux). Unfortunately, Debian is also known as one of the

most difficult distributions to install. This distinction, however, may change with the next official Debian release. A new installer, while not pretty, will greatly simplify Debian installation. We were able to use RC1 (Release Candidate 1) of the new installer for this article.

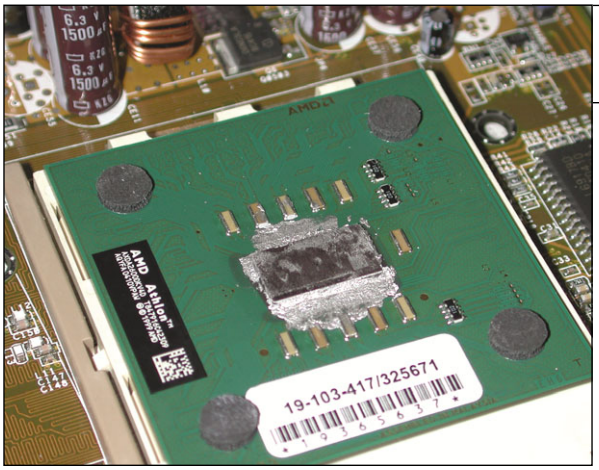
Before we begin, you should know there are three different Debian distributions: Stable, Testing, and Unstable (code-named Woody, Sarge, and Sid, accordingly). As the name implies, the Stable distribution is rock solid, but its software is dated. The Testing distribution is where developers update software and smash bugs until Testing is considered Stable. Sarge will eventually replace Woody as the official Stable release, and developers will create a new Testing distribution with a new code name. Unstable is always known as Sid, and it's the distribution with the most cutting-edge software but also the most bugs.

The new installer will accompany Sarge, so it installs Testing by default. We recommend this distribution for desktop users because the software is more current, but you're less likely to encounter major bugs. If you don't want to wait for the latest software, we'll show you how to upgrade to Unstable later in this article.

We downloaded the new installer from the Debian Web site (www.debian.org/devel/debian-installer) and burned it to a CD. You'll need to download the ISO Recorder Power Toy (isorecorder.alexfeinman.com/isorecorder.htm) to burn the ISO image to a CD. Once installed, right-click the ISO image and select Copy Image To CD (*NOTE: At press time, ISO Recorder didn't work with SP2, but an updated release should be available by the time you read this.*) We then inserted the newly created CD-ROM and rebooted the system. At the boot prompt, we typed linux26 to install using a 2.6 series kernel. The 2.6 series includes support for SATA.

After selecting our language and keyboard and setting a host name and domain name, we opted to Manually Edit The Partition Table. Linux doesn't do well with NTFS partitions, so you'll want to select the first entry (your C: drive in Windows) and make sure it's set to Do Not Use. Select Done Setting Up Partition to return to the previous menu and select #2. Highlight Use As and press ENTER. Select FAT32 and then select Enter Manually to provide a mount point (the directory in which this partition will be made available). Enter **/mnt/documents** and press ENTER. Select Done Setting Up Partition.

Finally, highlight Free Space and press ENTER. Select Automatically Partition The Free Space. When asked, opt to use Separate Partition For Home Directories.



Spread a thin layer of thermal paste over the processor die.

This will let you preserve your personal settings if you have to reinstall Linux. If you prefer a file system other than ext3, change it now. Otherwise, select Finish Partitioning And Write Changes To Disk. These changes will not affect your WinXP partition or My Documents partition.

Choose to install Grub to the master boot record when prompted. Grub will let you select which OS to boot. After ejecting the CD-ROM and rebooting, you'll need to make some post-install configurations. Simply follow the Debian prompts to create a root password, create user accounts, and set your time zone.

APT is Debian's famous package management system. When asked to configure APT, select http, select your country, and choose a mirror. (You can leave the proxy information blank.) After Debian downloads a list of available packages, you'll see a Software Selection menu. Highlight Desktop and press the Spacebar, then press ENTER. Debian will download, install, and configure a variety of desktop-related packages for you including some popular graphical environments such as KDE and GNOME.

Debian should be able to autodetect most of your hardware. When asked if you want to autodetect your monitor settings, say no, provide the proper horizontal and vertical refresh rates, and choose a proper resolution. When the Exim Configuration screen appears, select No Configuration At This Time. Ignore the warning about mail not functioning as we'll use SMTP and POP/IMAP instead of Exim.

Finally, you'll see a graphical login screen. Click the Session pull-down menu and select KDE. Enter the username and password you created earlier to log in.

Modifications. You'll want to make a few small additions to your new OS. Press ALT F2 and type **synaptic.** (Synaptic is a graphical front-end for APT.) Synaptic provides an overview of available packages for your system. We recommend you click Find and search for KDM. Click the box next to KDM in the search results and select Mark For Installation. Do the same for kernel-image-2.6.7.1-k7 (a special kernel compiled specifically for the Athlon XP), kernel-source-2.6.7, make, and gcc (We'll need these later.) Click the Apply button to install the packages. Debian will ask you if you want to use KDM or GDM as your login manager. Select KDM and press ENTER. The next time you reboot, you'll notice a different graphical login and you should be running the special Athlon XP kernel.

NVIDIA. Debian includes 2D drivers for our NVIDIA graphics card. If you want to play 3D games such as Tux Racer, you'll need to install NVIDIA's 3D drivers.

Download the latest Linux drivers from NVIDIA (www.nvidia.com). Before we actually install the drivers, we'll need to do a little work. Click the terminal button in the panel along the bottom of

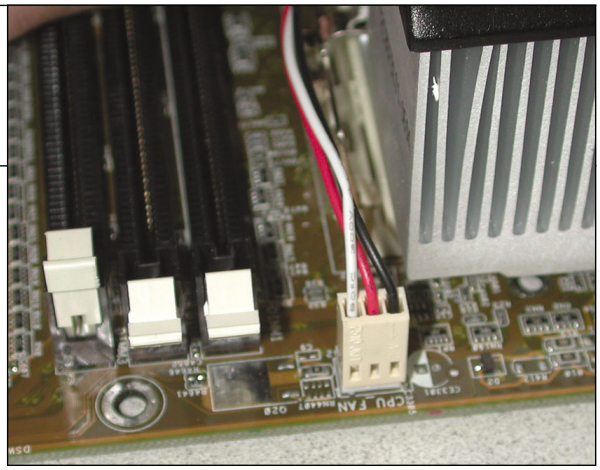
the screen (It looks like a computer monitor.) Type **su** and provide the root password when prompted.

Type **cd /usr/src** to move to the /usr/src directory. Decompress the kernel source you downloaded earlier by typing **bunzip2 kernel-source-2.6.7.tar.bz2**. Next, unarchive the files by typing **tar –xvf kernel-source-2.6.7.tar**. Create a symbolic link (similar to a Windows shortcut) to the newly created kernel-source-2.6.7 by typing **ln –s kernel-source-2.6.7 linux**.

You'll need to compile a copy of your old kernel. To do this, type **cp /boot/config-2.6.7-1-k7 linux/**. Move into the Linux directory (cd linux) and type **make** to compile the kernel. This will take a significant amount of time.

Once the kernel compile finishes, log out of your current KDE session. In KDM, click the Menu button and select Console Login. This will end your graphical session and leave you at the dreaded command line. Type **root** at the login prompt and provide your root password. Move to the directory where you saved the NVIDIA drivers and run the install by typing **sh NVIDIA-Linux-x86-1.0-6111-pkg1.run**. Accept the license and press ENTER to progress through the installer. It should eventually compile and install a driver for your kernel. The warning message about the NVIDIA license tainting the kernel is just letting you know you installed modules that aren't licensed under an open-source license. Type **killall kdm** and then **kdm** to return to KDE. If all went well, you should see an NVIDIA splash screen.

Documents. Open up the terminal again and type **ln –s /mnt/documents /*username* Documents** (where *username* is the user directory you created earlier) to create a symbolic link to the My Documents folder you created in WinXP. Any files you save in the Linux Documents directory will be available in the WinXP My Documents directory.



Make sure you connect the heatsink fan to the motherboard header. A burnt processor smells awful.

Upgrade. You can use Synaptic to upgrade to Unstable if you prefer. Click the Preferences pull-down menu and select Repositories. Select the second entry and replace Testing in the distribution field with Unstable. In the Section(s) field, add contrib and non-free to main. Make the same changes to the next line and remove the check from the final line. Click OK to save your changes, then click the Refresh button to update your list of available packages. Click the Mark All Upgrades button and select Smart Upgrade when prompted. Click the Apply button to install the upgrades.

You will need to install the newly upgraded packages. The default choice for most should be fine. Make sure you select psaux and PS/2 for your mouse.

Parts List

Component	Model	Price
Case	RAIDMAX Silence (811TP)	$55
Power Supply	Included with case	$0
Motherboard	ASUS A7V600-X	$67
Processor	Athlon XP 2600+ (Barton)	$85
Memory	Mushkin Basic Green PC2700	$41
Hard Drive	Hitachi 80GB 7,200rpm	$74
Video Card	Albatron NVIDIA GeForce FX 5600XT	$87
Sound Card	Integrated	$0
Network Card	Integrated	$0
DVD Writer	NEC 8x Silver DVD+/-RW	$64.99
Diskette	NEC 1.44MB Floppy Drive (Black)	$10.99
Monitor*	MAG InnoVision 772PFb 17-inch Pure Flat CRT	$99
Speakers	Cintre RW-6580D	$35.50
Mouse	Included with keyboard	$0
Keyboard	Keyboard-2000 Smart 1	$10
OS	Windows XP SP1a (OEM)	$87
Total		**$716.48**

*Monitor not actually purchased, but its price fits within our allotted budget.

Testing

From a performance standpoint, the system is lacking, but that's mostly due to the $750 price point. Our 3DMark03 score was a pitiful 870 and our PCMark04 score was just 2767. Our best showing came from the processor, which managed a 3121 CPU score. Our 860 Graphics score was disappointing, as was the 1952 Memory score. The 5088 HDD score, however, was very impressive. If you prefer something with more punch, you can easily create a system using more expensive components.

Final Remarks

The build itself was relatively easy. We did give this build a higher difficulty rating because you do need some familiarity with concepts such as hard drive partitioning. Because the installer we used is not an official release, there is a chance the Debian developers could change things up significantly before its release, so Linux experience is helpful. Nonetheless, anyone with a modicum of computer knowledge could successfully tackle this build. RS

by Chad Denton

Most All-Encompassing Multi-Drive System

Hit A Storage Grand Slam

Build #32 Skill Level: 1 **2** 3 4 5 ***Apprentice***

Honestly, most of us only need a handful of storage drives on a PC. A CD or DVD burner is pretty essential these days and cheap to feed. Add a USB flash memory drive for impromptu file transfers, plus a floppy for BIOS updates and DOS-based diagnostics, and you're pretty much set.

That all changes if you're running an advertising, marketing, or graphic arts firm. Clients may hand you ad ideas, product photos, or artwork on any type of media, and your computer had better be able to read them. If your computer *can't* read your customers' obscure disks or flash memory cards, they'll wonder just what kind of business you're running.

Show your clients that you're on the ball and your company is worth their business. Build a multi-drive PC that's as all-encompassing as you can afford.

Goal

With a budget of $1,500 or so, our challenge was to build a fast, usable PC that would support the majority of removable media you're likely to encounter these days. We had to leave out a lot of formats at this price; check our online "Other Format Options" sidebar in this article for more possibilities.

Also, our focus for this PC was on different types of drives. For a variation on the "all-encompassing" theme—one that incorporates multimedia and wireless networking—flip to page 176.

Background

For a multi-drive mule, it's critical to buy a case with enough drive bays—especially externally accessible ones for floppy, CD/DVD, and other removable media drives—as well as a motherboard with plenty of connections, such as USB 2.0 ports, for future devices. We also bought a power supply that would be able to fuel all these drives without browning out.

It's also critical not to buy too many drives that use the same interface. For instance, most motherboards only offer two ATA/EIDE headers, for a maximum of four EIDE hard drives and ATAPI devices, such as DVD, Zip, and card readers. Buying a SATA hard drive or external optical drive alleviates crowding on the EIDE channels. If you do use up your allotment of EIDE, USB, or FireWire connections, you can add a controller card or hub to support new drives.

Sony's DRU-700A drive covers all the commonly available optical formats you're likely to need: DVD-R/RW, DVD+R/RW, CD-R/RW, and 8.5GB DVD+R DL (double layer). At press time, there were no "triple DVDs"—DVD-RW, DVD+RW, and DVD-RAM drives—that also support DL. The older DVD-RAM has a broader installed base at the moment, so you might opt for an LG ($68) or Iomega ($214) triple DVD now and add a DL drive later.

We skipped tape drives, as your clients will more likely use these to back up their own data instead of distributing files to you. However, we did include Iomega's new REV drive, with 35GB native/90GB compressed magnetic disks, as a fast backup device for this PC. We briefly considered Iomega's recent Zip 750 drive, but it can only read, not write, the far more common Zip 100MB disks. On the other hand, a Zip 250 can read and write both 250MB and 100MB disks, covering the overwhelming majority of Zips in the world.

Iomega's Jaz 2GB SCSI drive made the list because of its huge installed base among graphic artists and other creative types in years past. It's also read/write compatible with 1GB Jaz cartridges. We had to add a SCSI card to support the Jaz, but this would also let us upgrade to speedy server hard drives down the road. One snag: The LSI Logic LSIU160 SCSI card we bought to replace an out-of-stock adapter only had 68-pin headers, and our Iomega Jaz drive had a 50-pin SCSI connector. Even worse, the LSIU160 needed a longer 64-bit PCI slot, found on various server boards but not on our desktop Epox motherboard. We scrounged up an Adaptec AHA-2940UW Wide Ultra SCSI card for 32-bit PCI with a 50-pin header, and actually saved a few bucks

Here are some of the drives and adapters we bought for our multi-drive PC. That SCSI card at the lower left didn't work out.

($13). The downside is a 40MBps speed limit, but that won't affect our Jaz.

Finally, to cover digital cameras, personal music players, and other mobile devices, we added a SanDisk SDDR8807 ImageMate 8-in-1 USB 2.0 reader/writer. This supported most types of flash memory cards, including new ones such as xD-Picture Card. However, we didn't find the fine print until much later; the ImageMate won't support Hitachi Microdrives because the bus doesn't supply enough power. Shop around for a different reader if you need Microdrive support.

Parts List

The Iomega REV drive, for all its speed and capacity, ate up the biggest share of our budget. Alternatives include tape drives, DVD-RAM, or emerging blue-laser optical disc formats such as PDD, Blu-Ray, and HD-DVD.

Component	Model	Price
Case	RaidMax 278WBP Mirage ATX Mid Tower	$38
Motherboard	Epox EP-8HDA3+ *	$99
Processor	AMD Athlon 64 2800 1.8Ghz 512K Cache	$187
Memory	256MB MemoryPRO (2x128MB) DDR400 PC3200	$52
Hard Drive	160GB Maxtor 6Y160M0 SATA 7200rpm 8MB cache	$105
Video Card	Sapphire Atlantis Radeon 9200 SE AGP 128MB TV-Out *	$42.62
Optical Drive	Sony DRU-700A double-layer DVD±RW	$160
Monitor	Samsung SyncMaster 753DF (17-inch, 1280x1024, .20mm)	$119
Floppy Drive	Sony MPF920ZCU1 3.5in 2HD Floppy Drive Internal	$4.88
Power Supply	Antec True430 430W	$59
Mouse	Logitech Optical Wheel 3-Button Mouse	$8.59
Keyboard	Belkin ErgoBoard USB / PS/2	$16
Operating System	Windows XP Home Full OEM version	$90
Miscellaneous	Compuman 80mm case fan; misc. bolts, nuts *	$10
Other Drives	Iomega Zip 250MB internal ATAPI	$30
	SanDisk SDDR8807 ImageMate 8 in 1 USB 2.0 Reader/Writer	$26
	Iomega REV 35GB USB 2.0 external	$305
	Iomega Jaz Drive 2GB Ultra SCSI (50-pin) internal	$51
Other Adapters	Adaptec AHA-2940UW Wide Ultra SCSI (50-pin, 68-pin) card *	$13
	SIIG FireWire 800 PCI-32T (NN265) card	$42.64
Total		**$1,458.73**

NOTE: Tax and shipping costs are not included.
* Equipment previously purchased.

The Build

Our RaidMax case, like most computer cases, had stamped perforations covering the drive bays, expansion slots, and ports area. When we needed to install a drive or card, we often had to push out the perforated knockout plate in our way, watching out for sharp edges. Bending a stubborn plate back and forth works very well to break it loose, although you might need a screwdriver to press, pry, or twist the plate out enough to get a grip on it. Take care not to bend the case or stab any electronics.

The plastic knockout plates in the front panel are easier to push out. Just unlatch their retaining tabs with a fingernail. Our front panel's mounting pins were broken, but some of them still held the fascia to the case.

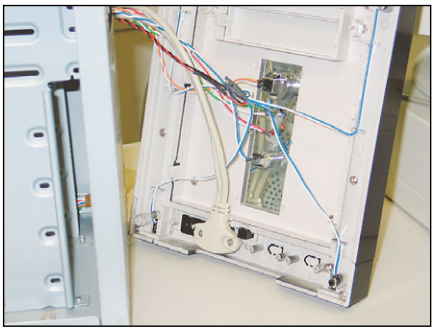
Working with the case lying on its side and its side panels removed, we swapped the beefy Antec power supply into the RaidMax supply's place. We then screwed standoffs into the case's inner panel under each of our motherboard's silver-lined mounting holes and secured the board into the case. The 20-pin and 4-pin power harnesses clicked into their sockets on the motherboard. Next, we snapped our RAM modules into the slots closest to the CPU socket and then installed the Athlon 64 with a temporary lift of the socket lever.

There's a trick to installing an Athlon 64 heatsink. Set it down on the processor, first making sure there's some thermal compound in between. Our retail Athlon 64's sink came with thermal putty already applied. With the cam lever facing you, keep it turned up and to the left as you attach the metal clips to the socket tabs. Then turn the lever down and to the right with moderate thumb pressure until its plastic retaining arm hooks under the tab on the right corner of the socket. Slip the fan's power cable onto the CPU FAN header on the motherboard, and you're done.

Make sure each drive fits flush with the front panel before you tighten it in place.

After flattening a raised section in front of the 3.5-inch drive bays with a bolt, nut, and washers, we installed an extra 80mm cooling fan there. We also turned the case's side panel fan to blow inward. Good airflow will be important with all the devices we plan to install in this system.

Forming attachments. The front panel's connections were next. We attached the front LEDs, switches, and USB ports to the motherboard, following the Epox manual. Next was the external SATA and joystick/MIDI bracket. Note that the Epox manual showed the gameport/MIDI header upside down from the way it was on our board. As with EIDE and floppy



The inside of the RaidMax case's front panel shows the USB, LED, and switch wiring.

System Notes

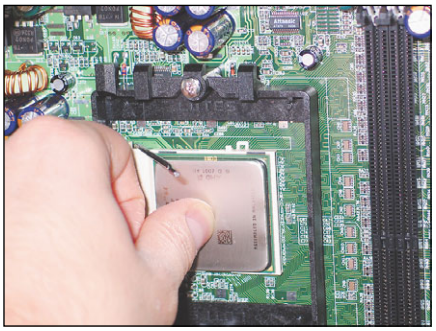
We ran PCMark04 (version 1.2.0, with Windows Media Player 9) and 3DMark03 (build 340, with DirectX 9.0) at default settings; HD Tach 3 with 32MB zones over the entire 160GB drive; IOmeter 2003.5.10's File Server test at one user, 16 outstanding I/Os; IOmeter's Web Server test at four users, 64 total outstanding I/Os; both run on the second 10GB partition of the drive. The ATI video card drivers were Catalyst 4.7.

PCMark04	
System	2920
CPU	3329
Memory	3280
Graphics	603
Hard Drives	4726
3DMark03	443
HD Tach 3	
Average read (MBps)	48.9
Maximum read (MBps)	60
Burst read (MBps)	100.7
Random access (ms)	13.7
IOmeter	
(inputs/outputs per second)	
File server	113.13
Web server	147.55

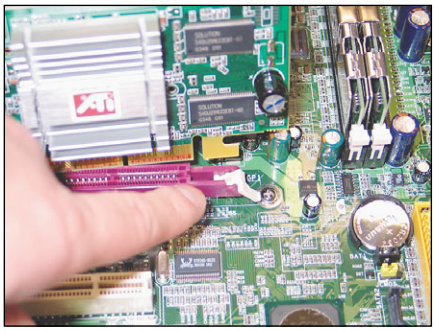
cables, orient the gameport/MIDI cable's red stripe toward pin 1 on the header.

We secured the Radeon video card in the AGP slot using a bracket screw and the slot's retaining lever. Next, we connected the monitor's VGA cable to the card. After plugging the monitor and Antec power supply into a surge protector, we started the PC and pressed DELETE to enter the BIOS Setup. Here, we changed SATA Mode to IDE (as opposed to RAID); set PNP OS Installed to Yes, as Windows XP is a Plug-and-Play OS; adjusted the boot device order to a floppy, CD-ROM, and hard drive, in that order; enabled support for our USB keyboard and mouse; changed the time and date; and set the AGP slot as the initial display path. We saved our changes and exited and then shut off the PC again.

We set our Sony DVD drive's rear jumper to the Master position and then bolted the drive in the top 5.25-inch bay using four screws. The floppy drive went into one of the externally accessible 3.5-inch bays. We used the end connectors on Epox's ribbon cables to link our DVD and diskette drives to the motherboard. This is important, as the middle connector on an



Hold the Athlon 64 down and then lower the socket's lever until it locks. Our 64's heatsink came with thermal paste already applied.



Flip the AGP retaining lever up to keep your graphics card seated, especially if your card has a heavy heatsink.

EIDE cable is for the slave device (set by its rear jumper), whereas the middle of a floppy cable is for the B: drive rather than A:. The Antec people supplied power cables to both. Adjust the floppy and DVD drives so they fit flush when the case's front panel is in place.

Because we wouldn't be feeding it media like the floppy drive, we screwed the 160GB Maxtor hard drive into one of the bottom 3.5-inch bays without external access. We powered the hard drive with one of the Antec power supply's SATA-style leads, conserving the 4-pin Molex power cables for other drives. We connected a SATA data cable between the drive and one of the headers toward the bottom of the board, near the Silicon Image 3114 controller chip.

Win-doze. Time to install WinXP. We inserted the Windows CD as the PC rebooted and then pressed F6 when the quick prompt asked us if we wanted to install third-party SCSI or RAID drivers. We supplied the Silicon Image driver diskette Epox had provided and then followed the on-screen directions. If you connect your SATA drive to one of the headers by the VIA VT8237 southbridge, insert the VIA SATA driver disk instead.

In Windows Setup, we created two 10GB partitions, one for WinXP and one for our applications. We created a third partition from the remaining 136GB for data. We then let Setup format the C: partition with the NTFS file system and install Windows.

As we've come to expect, Setup warned us twice that our SATA drivers weren't approved by Microsoft. We clicked Yes to install them anyway. We noticed that the Epox motherboard didn't lose support for our USB mouse and keyboard halfway through the installation, as did the DFI NFII Ultra Infinity board we used in other articles.

When WinXP completed its installation, we clicked Start, Control Panel, Switch To Classic View, Administrative Tools, Computer Management, and Disk Management. Here we right-clicked and formatted the E: and F: hard drive partitions we'd created in Windows Setup. Next, we ran Windows Update and then installed the latest drivers for the Epox motherboard and Radeon graphics card.

From here, we started a procedure of installing our new drives and cards one at a time. We needed more screws than came with our case and devices; a computer store may sell or give you a few of the right thread pitch and diameter. We installed the latest drivers from the manufacturers' Web sites for each device and made sure each one worked before adding something else. If we had simply connected everything before turning on the computer on the first time, we would have a hard time figuring out which device was keeping our system from booting. More on that later.

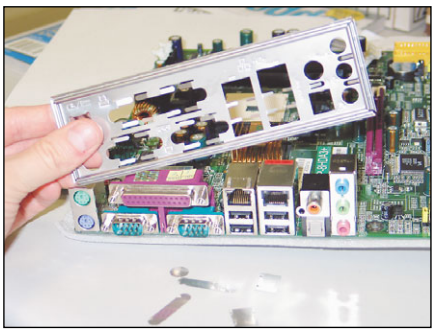
Our Zip drive was an ATAPI device, which meant that it could attach to one of the motherboard's EIDE headers via hard drive cable. We put it on a different ribbon cable and header (IDE2) than the DVD drive (IDE1), so that the older Zip drive wouldn't slow down the optical

drive's data transfer speeds. However, because the refurbished Zip drive didn't come with a jumper to set it as the Master device on that cable, we left it as a Slave without a jumper (according to its label diagram) and attached it to the middle connector on the cable. Master devices work best on the end connector. It doesn't matter whether a sole device on an EIDE cable is a Slave or Master, just as long as it's on the right connector and its jumper is set correctly.

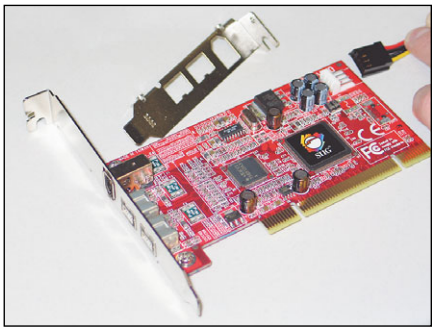
Feeling SCSI. Initially, WinXP said that it couldn't find drivers for our Adaptec AHA-2940UW SCSI card. Adaptec's site only supplied support for the card up through Windows 2000. Later, however, WinXP automatically found drivers that would work. Huzzah for Microsoft! (Er, don't tell anybody we said that.)

Our Jaz drive came with brackets to mount it in a 5.25-inch bay, plus a bezel to fill the extra space in the front panel. That was a lucky break for us, as the floppy and Zip drives occupied both external 3.5-inch bays. After connecting the Jaz to the Adaptec card and power supply, we rebooted and pressed CTRL-A to enter the SCSISelect Utility. We enabled Support For Ultra SCSI Speed here. Host Adapter SCSI Termination was set to Automatic, so we didn't have to worry about an unterminated SCSI chain causing problems. Everything else looked OK, so we saved our changes and exited.

Unfortunately, with the Jaz drive attached to the SCSI card, WinXP wouldn't start. The PC was trying to boot from the Jaz. In SCSISelect's Advanced Configuration Options, we changed Support Removable Disks Under BIOS As Fixed Disks to Disabled. Its previous Boot Only setting had caused the Jaz to usurp the C: drive letter, preempting our SATA hard drive. We saved our changes and exited.



Just look at all these ports on the Epox motherboard. The metal part is called the I/O shield, by the way.



Our SIIG FireWire 800 card came with an extra bracket to fit low-profile and SFF computer cases. Note that the card takes a floppy-style power lead, shown at right.

Our SIIG FireWire card, like many recent video cards, required an auxiliary power cable. Luckily, our Antec power supply had a second floppy-style connector. After installation, we followed SIIG's instructions to update the card's drivers. We had to force WinXP to install the specific driver we'd just downloaded from SIIG; it wouldn't accept that SIIG's new driver was "better" than its 3-year-old driver. With all the data cables in a system like this, it's important to route power and data lines out of the way for better airflow. Nylon ties can help.

Next, we installed the REV drive's software per Iomega's instructions. When the install routine shut down the PC, we connected the drive to a power strip and a USB 2.0 port and then rebooted. Another minute later, WinXP finished the installation process. The chunky, $60 REV cartridge included with the drive, smaller but thicker than a Zip disk, offered 35GB of uncompressed magnetic storage space on a rigid metal platter. Curious about this challenge to optical media's dominance in removable storage, we timed a drag-and-drop transfer of 491MB from the hard drive to the REV. It took 27 seconds, which indicated an 18.2MBps write speed, at least for the first percentage or two of the cartridge's space. Our REV read the data a couple of seconds faster, or 19.6MBps.

Finally, we hooked up our bus-powered SanDisk ImageMate card reader to a USB 2.0 port. WinXP recognized it and supplied the drivers it needed.

Testing

This PC should have been comparable in speed to the RAID 1 and single-drive PCs in the benchmark chart in ARTICLE 24, yet it lagged a little in CPU and memory tests. The graphics difference is obviously the result of a cheaper Radeon card. However, the other disparities are probably the result of the processing overhead the additional drives and adapters require from the CPU, even when idle. In other words, every drive or card you add to a system might slow down overall performance a smidgen.

Final Remarks

Keep in mind that you're bound to run into media that your system can't handle. It's inevitable, in light of all the new flash memory cards muddying the mobile device market. You'll also encounter defunct, dead-end formats still used in small numbers, such as the Peerless and Castlewood Orb.

One option is to ask for the files on CD or DVD or through email. You might also consider adding the necessary drive to your arsenal. A last resort is to ask the client to bring in her oddball drive so you can hook it up to your PC. RS

by Marty Sems

Here's our finished system. Heck, we even had a few drive bays left over for a future DVD-RAM or tape drive.

Build A Music Server With Multiple Receiver Nodes

Do You Know Where Your Music Is?

Build #33 Skill Level: 1 2 3 4 5 *Apprentice*

You've ripped your audio CD collection and bought hundreds of songs online. Your computer stores all of your music. You've grown tired of playing your songs on your PC's speakers, but you aren't prepared to lose the tremendous music storage potential of a desktop PC. In this article, we'll show you how to not only play your computer's music on your home stereo, but also pipe music from the PC to several locations throughout your home.

Goal

We'll design a versatile music server that supports a variety of media formats and will be able to stream music files to multiple locations simultaneously. We'll use music equipment that includes the ability to play one family member's music in the kitchen at the same time that it plays another family member's music in a home office.

Our system will include both analog and digital audio connections. This way, we can have considerable freedom in choosing audio components if we want to add more nodes in the future.

Finally, because our music server will replace the racks of CDs most people are familiar with, our music server and its associated equipment should also be intuitive so that even guests to our home can figure out how to change the music on the stereo.

Background

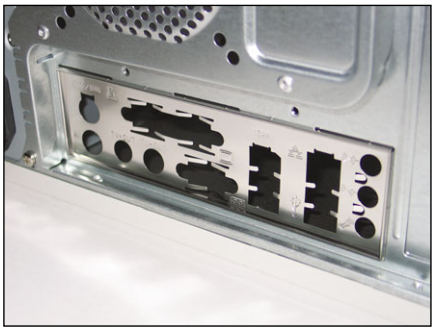
The easiest way to set up a music server is to start with a music receiver specially designed for streaming music from a PC to an audio device, such as a stereo receiver. Many companies make such products, so we had to do a little bit of research, investigating not only which products support the most media formats but also which earned the highest user ratings. In the end, we felt quite confident in our decision to buy Slim Devices' Squeezebox ($199; www.slimdevices.com).

The first thing we noticed was that Squeezebox supports many file types (MP3, WMA, AAC, Apple Lossless, Ogg Vorbis, and FLAC compressed audio files, and both WAV and AIFF uncompressed audio files). In addition, you can use Squeezebox to stream SHOUTcast Internet radio (www.shoutcast.com). Furthermore, the Squeezebox receiver provides several types of audio outputs, including analog and digital, with RCA, SPDIF, and 1/8-inch audio-out ports.

Another thing we liked about Squeezebox is that it is small, includes its own IR remote control, and has an LED display, eliminating the need for a separate display for navigating tracks. Many other music servers require that you use your TV to view menu options and select music. We wanted music receivers that would connect to any type of stereo system and require no additional equipment so that we could easily place the receivers throughout a home. We selected the wired version of the Squeezebox; Slim Devices also makes a wireless version for just $50 more. The wired version of the Squeezebox comes with a 10-foot Ethernet cable to connect the receiver to either a router or a PC. If you need to place the music receiver more than 10 feet from the router or computer, measure the distance and buy an appropriate length of cable for each of the receiver nodes. Also, if you connect the receivers directly to the computer instead of to a router, you should buy crossover cables instead of standard Ethernet cables.

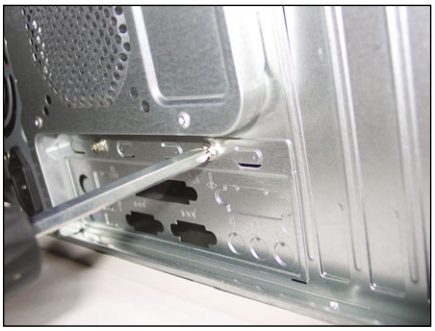
You can easily install Squeezebox on your existing PC, but we decided to build our own music server from scratch. The ASUS P4R800-V Deluxe motherboard is the central component of our server. This motherboard has integrated video, audio, and other essential functions. It also has a SPDIF port, four Hi-Speed USB 2.0 ports, a FireWire port, and an RJ-45 Ethernet port. We could have splurged for an add-on sound card, but we felt that expense was unnecessary. We needed only basic audio capabilities on our machine because it would send the music to our stereo system.

We chose a 160GB 7,200rpm Samsung hard drive because it would offer ample space for audio files. We bought an APEX Mid-Tower Super Case that has extra



We pressed the new backplane into the case until it locked into place. As you can see, the backplane has openings for the ASUS P4R800V Deluxe's FireWire, Hi-Speed USB, and other ports.

We twisted several standoffs into the corresponding holes in the case. These were to prevent the back of the motherboard from touching the case.



We replaced the standard backplane with the one that came with our motherboard.

drive bays, so as our music collection grows, we can add more hard drives later.

We found a good deal on a Sony CD-RW/DVD-ROM combo drive with CD read speeds up to 52X that's ideal for quickly ripping CDs. The DVD capabilities are a nice addition, especially if you have DVD Audio titles in your collection or music stored on recordable DVDs.

Although we planned to play our music on home stereo systems, we did buy a reasonable set of speakers so we could listen to files on our server, as well. We wanted to go with a name brand, and a 2.1-channel Altec Lansing set of speakers for $39.99 seemed like a good value. If you want to save money on your system, keep in mind that you can buy a cheap $10 pair of PC speakers, or you can skip speakers altogether.

We decided to connect our server and receivers to our existing router. If you don't have a router already, we would suggest buying one, as it makes it very simple to set up a music server. However, the router isn't necessary if your PC has an Ethernet port for each music receiver node. If you don't have enough Ethernet ports, you can add network cards to the motherboard's PCI slots to gain extra network ports.

To set up the device without a router, you would first enter the network options (the exact phrasing varies depending on the Windows version) in the Control Panel and manually configure a static IP address for the PC. (For example, you might use 10.0.0.1 for the PC's address.) When we set up our music receivers using the router, we let the receivers find IP addresses automatically. If you don't use a router, you would instead need to use the music receivers' remote controls to set a static IP address that's in the same range as the PC's IP address. (For example, you might assign the first music receiver node an IP address of 10.0.0.2 and the second music receiver node an IP address of 10.0.0.3.) As you will see, we found that setup was much simpler using a router.

The Build

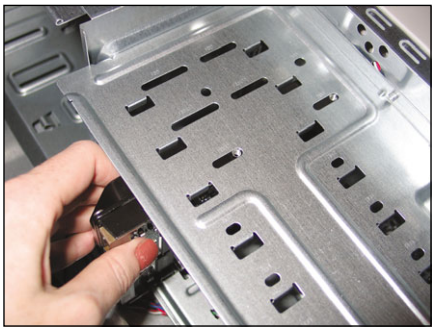
We started the build by opening the case. This APEX case opened fairly easily. We unscrewed the thumbscrews on the left side of the back of the case that held the left panel in place. Then we set the case on its right side and slid the left panel off by pushing it toward the back of the case.

Install the CPU and fan. Next, we set the motherboard on the antistatic bag in which it was packed, and we unpacked the processor we'd bought. We aligned the corner of the socket with the arrow with the corner of the CPU with the arrow and gently dropped the processor into the socket. Because Pentium 4 CPUs

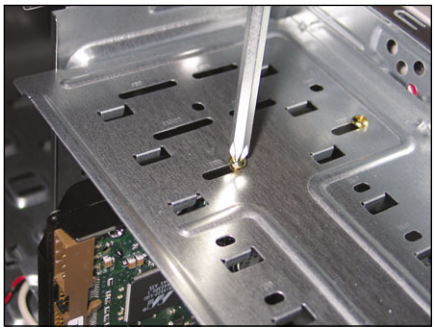
Parts List

Part	Model	Price
Case	APEX beige Mid-Tower SuperCase 7C574-115	$22
Power Supply	350W (came with case)	$0
Motherboard	ASUS P4R800-V Deluxe	$99
Processor	Intel Pentium 4 3.2E GHz 800MHz FSB, 1MB L2 cache with HyperThreading (retail)	$279
Memory	Kingston PC3200 DDR400 512MB	$106
Video Card	N/A (ATI Radeon 9100 IGP chipset built into motherboard)	$0
Sound Card	N/A (SoundMAX AD1888 6-channel audio built into motherboard)	$0
Network Cards	N/A (motherboard has Marvell 1xLAN port)	$0
Hard Drive	Samsung SP1604N 160GB 7,200rpm IDE hard drive (OEM)	$93
CD/DVD Drive(s)	Sony CRX320E beige 52X/32X/52X/16X CD-RW/DVD-ROM combo drive (OEM)	$43.99
Floppy Drive	N/A	
Monitor	N/A	
Keyboard	Logitech diNovo Media Desktop cordless keyboard	$199
Mouse	Logitech diNovo Media Desktop cordless mouse (came with keyboard)	$0
Audio Equipment	Altec Lansing 221 2.1 amplified speaker system	$39.99
Other Hardware		
	Slim Devices Squeezebox Wired x2	$398
	10-foot CAT5 Ethernet cable	$4.99
	AUDIO 11A1-16424 18-inch 2-Pin connector SPDIF cable (OEM)	$1
Software		
	Microsoft Windows XP Home Edition (bought on sale; clearing out SP1 in anticipation of SP2 release)	$89
Total		$1,374.97

The motherboard's ports lined up with the proper holes in the case's backplane.



The hard drive slid easily into one of the drive bays marked "HDD."



We used two of the screws that came with the hard drive to secure the drive to one side of the 3.5-inch drive bay.

are notorious for having easily-bent pins, we were careful not to press on the processor at all, letting it drop into the socket on its own. Then we locked the CPU in place by pulling the socket lever down against the motherboard. Next, we installed the CPU fan, following the instructions detailed in the users manual that came with the P4 processor.

Replace the backplane. Our motherboard came with more ports and features than many motherboards do, so it was necessary to replace the standard backplane of the case with a backplane that came with the motherboard. We removed the screws that held the backplane to the case and then pressed the piece off the back of the case. We did not need to screw the ASUS-supplied backplane into place. Instead, we just pressed it against the inside of the case until it clicked, locking into the case. The new backplane had extra openings for the ASUS P4R800V Deluxe's featured ports, including one FireWire and four USB 2.0.

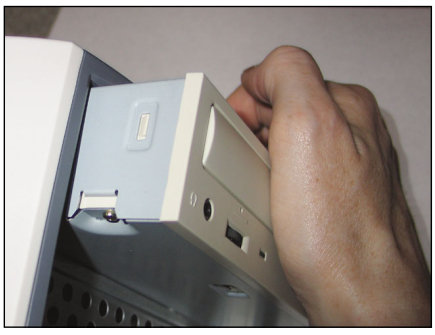
Install the motherboard. Before we could install the motherboard, we needed to add several standoffs to the case to ensure that the motherboard would not touch the side of the case. The standoffs came with our case, and they simply twisted into each of the precut holes inside the case that corresponded to one of the holes in the motherboard. After lowering the motherboard into the case, threading its ports through the backplane openings, and lining the motherboard's holes up with the standoffs, we screwed the motherboard to the standoffs. Then we attached the IDE cable that came with the motherboard to the motherboard's Primary IDE slot. We were careful to line the striped edge of the IDE cable up with Pin 1 of the IDE slot.

Install the hard drive. This case made it very simple to install the hard drive. We simply slid the hard drive from the inside of the case forward into one of the bays labeled HDD, being careful to make sure the screw holes in the drive were visible through the slots in the hard drive bay. We used two of the screws that came with the hard drive to attach the drive to the bay. This secured only one side of the hard drive, but we didn't need to remove the right panel of the case to screw the other side of the drive to the bay. The hard drive bay had support ledges that held the other side of the drive firmly in place without the use of additional screws.

We connected the loose end of the IDE cable we'd attached to the motherboard to the back of the hard drive, once again lining the striped edge of the cable up with Pin 1 of the IDE slot. We took one of the power supply's connectors and plugged it into the back of the hard drive, as well.

Install the CD-RW/DVD-ROM drive. To install the optical drive, we needed to remove both the top drive bay panel (where we intended to install the drive) and, temporarily, the panel beneath it (so the drive could slide into place). It was easy to grasp the side of each panel and pull the panel off the front of the case.

Next, we pushed the combo drive into the bay by inserting it into the front of the case and pushing it until the drive's bezel was lined up with the front of the case.



After removing a pair of drive bay panels from the front of the case, we gently slid the CD-RW/DVD-ROM combo drive into place.

System Notes	
Physical Description	
Height	18.75 inches
Width	7.25 inches
Depth	16 inches
Weight	20.54 pounds
Other Physical Details	Music receivers are each 1.9 inches high x 8.5 inches wide x 4.5 inches deep.
Hits & Misses	
Outstanding Features	Supports up to 800MHz FSB, has a Wi-Fi slot for optional wireless LAN, RAID 0/1/0+1 and JBOD support, FireWire port, S/PDIF-out port, Gigabit Ethernet, ASUS Q-Fan, AI Overclocking, ASUS C.P.R., adjustable FSB/DDR ratio, six Hi-Speed USB 2.0 ports, four SATA ports, and independently operating music receivers with custom remote controls.
Weak Links	This system only transmits audio, not video. Due to fast CPU and other extras, this system is more expensive than a functional music server needs to be.
Performance	
3DMark03	764
PCMark04	4420

To hook up the optical drive, we connected one end of an IDE cable to the back of the drive and the other end to the secondary IDE slot on the motherboard.

Then we used a pair of screws to secure the drive to the bay. We connected one end of an IDE cable to the back of the DVD drive (once again ensuring that the striped edge lined up with Pin 1 of the slot) and the other end to the Secondary IDE slot on the motherboard. Finally, we attached one of the power connectors to the back of the combo drive and replaced one of the two panels we'd removed by placing it over the bay beneath the DVD drive and pushing it back onto the case.

Add memory. According to the motherboard manual, we could install our Kingston DDR in either the blue or the black DIMM slots. We inserted each of our PC3200 DDR SDRAM modules in one of the blue DIMM slots on the motherboard, pressing the module down until the side levers snapped into place around the ends of the memory.

Add backplane expansion pieces as desired. Several expansion pieces came with the ASUS P4R800V Deluxe motherboard, including a digital-audio output connector card with SPDIF and coaxial outputs, a piece with a game port and two extra Hi-Speed USB 2.0 ports, and a backplane with a serial port to make a system compatible with older peripheral devices. We had to forgo installing the piece with the game port and USB ports because our motherboard had only two spare USB headers and our case had two front USB ports. We thought the front USB ports would be useful for easily transferring music from our server to a portable MP3 player or other device, so we connected these ports to the headers as described on the APEX instruction sheet.

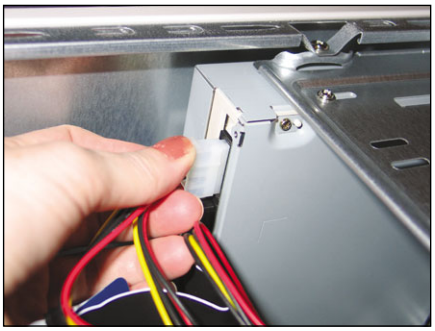
To install each set of add-on ports, we removed one of the PCI card backplanes from the back of the case. With some cases, you remove a screw and lift the backplane out, but with this case, you need to press the perforated metal until they pop out. We were careful to press from the inside of the case so as not to cause the backplane to fall into the case, which could damage motherboard components. After we removed each backplane, we placed one of the expansion cards so that its ports were available through the now-exposed opening in the back of the case. Then we screwed the card's bracket to the back ledge of the case.

Connect the power supply. As we neared the end of the build, we plugged the largest of the power supply's connectors into the power socket of the motherboard. We also plugged the power supply's four-pin power connector to the four-pin power socket, which was located in the vicinity of the CPU.

Finish building the PC. We slid the left panel back onto the case and replaced the two thumbscrews we'd removed from the back of the case. Then we set the tower upright and attached our monitor to the back of the case. At this point, we set up our cordless keyboard and mouse to work with the system. Then we connected the power cord, plugged it into an open socket on our surge protector, and turned on the computer and monitor.

After installing Windows, we placed the ASUS installation CD in the optical drive and installed the motherboard's accompanying software and drivers. This was important because some peripheral devices wouldn't work later unless we installed the ASUS drivers at this point.

Set up music receivers. It was very simple to set up our music receivers. We simply used the supplied 10-foot Ethernet cables to connect each of the receivers to the router. Note that if you want to place a music receiver more than 10 feet from your router, you should either buy a longer Ethernet cable or buy the wireless version of Slim Devices' Squeezebox. We then placed each receiver in its desired location



We attached one power connector to the back of the combo drive and another to the back of the hard drive.

and used the supplied A/V cables to connect the audio ports of each music receiver to the audio-in port of the corresponding stereo system we wanted to use for that device. Then we attached a Squeezebox power cord to the back of each Squeezebox receiver and plugged the devices into an outlet. Finally, we inserted two AAA batteries in each of the Squeezebox remote controls. Slim Devices even supplied the first pair of batteries with the Squeezebox.

Download and install music server software. Next, we connected our PC to the router using an Ethernet cable, turned the PC on, launched our Web browser, and went to Slim Devices' Web site to download the free Slim Server software. The installation of Slim Server was very simple, so we were ready to configure our music receivers.

Configure music receivers. It was much easier than we expected to configure the Squeezebox music receivers. To set up the first receiver, we pressed its remote control's power button. The LED display on the front of the receiver can display two lines of up to 40 characters simultaneously, allowing plenty of room for the Squeezebox to display the receiver's menu options and setup instructions.

After we pressed the remote control's power button, a message on the LED display spelled out, "Hello. Welcome to Squeezebox." The LED screen walked us through every aspect of the setup, first prompting us to Set Up Networking. We used the remote control's arrow buttons to navigate menus on the LED screen and chose Obtain IP Address Automatically

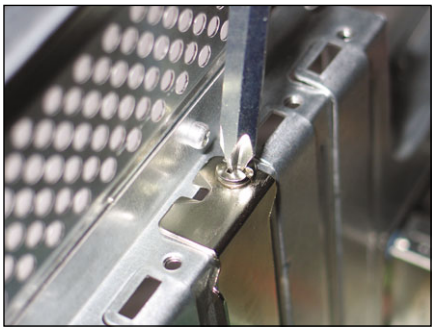
(DHCP) rather than Specify A Static IP Address. The Squeezebox then searched for the IP address the router had assigned. Once it found the IP address of our PC, it displayed the name of the computer and the IP address on the LED display. We could see that this was the same computer we had just built. Once we accepted the IP address, the Squeezebox display read, "Setup is complete!"

We were impressed that Squeezebox automatically updated its own firmware. An LED message indicated that Squeezebox needed to install a software update and that we needed to press and hold the Brightness key on the remote to begin. Within a matter of seconds, the Squeezebox music receiver had updated its firmware and was ready for action. In fact, we could already use the remote to select Browse Music Folder, and the Squeezebox LED displayed the two sample music files that Microsoft included with our Windows installation. When we selected a track and pressed the Play button on the remote, the music from our PC started to play on our home stereo's speakers. We could browse tracks by categories named Title, Artist, Album, or Genre.

In addition, we could use the remote control to input an artist name or word for which we wanted to search, and the Squeezebox display would return search results from our music collection. Obviously, we didn't need the Search function at this point, when we had only two music files, but after we ripped many of our audio CDs, the Search function was indeed a blessing.

After we hooked up and configured the first Squeezebox music receiver, we then turned our attention to the second Squeezebox and repeated the setup and installation process. Every aspect of the installation was the same for the second unit, and when we were done, we had two music receivers, each serving different songs to their respective stereo systems.

Explore the Slim Server software. Now that we knew our music receivers worked, we were ready to rip some CDs and build up the collection of music in the My Music folder (which is where Slim Server automatically looks to find your music). To add



We used a screw to fasten each extension card to the inside of the back of the case.

music, we launched Windows Media Player. (Although we could have downloaded any media player that can rip tracks to MP3, WMA, AAC, or another of Slim Server's supported file formats.) After ripping the tracks and ensuring that they were placed in the My Music folder, we used the Squeezebox remote control to navigate the menu and select Refresh My Music Folder.

Slim Server had many more features than we could discuss in the limited space here, but we'll cover a few of our favorites. First, you can use Slim Server's Web-based interface to stream your music from your music server over the Internet to any PC that has a program such as WinAmp or iTunes installed.

Slim Server also supports Internet radio streams. In fact, SHOUTcast radio stations are built into the Squeezebox's menus, so we could select SHOUTcast and browse to find a music channel we liked. You can add other music channels by placing a shortcut to the Internet radio channel in your My Music folder.

Another bonus for many users is that Slim Server is open-source and written in Perl. Because of this, there are many revisions to the software. You can also find many interesting Slim Server plug-ins at www.slimdevices.com/dev_plugins.html, including plug-ins to stream BBC radio, view song lyrics on the Squeezebox screen, play blackjack on the media receiver, check the weather forecast, and even check your email on the Squeezebox.

Although many of these functions have little to do with serving music to a stereo system, those who enjoy writing programs or tweaking gadgets will appreciate the freedom and accessibility Slim Server's open-source code provides.

Testing

In terms of sheer usability, our music server gets high marks. We were surprised by how easy it was to set up the music receivers, configure the software, add new music to the server, and send different songs to more than one receiver simultaneously. The most difficult part of this system was actually building the PC; however, we really didn't encounter any problems there either.

To put our music server to the test using more objective criteria, we ran Futuremark's 3DMark03 and PCMark04 on our system. Although we did not build this system for gaming, it performed relatively well in the 3DMark03 tests, completing three of the four game tests and returning a score of 764 3DMarks.

We were also pleased with the performance of our system when we ran the PCMark04 benchmarks. The overall score was 4420, and, not surprisingly, given the ultra-fast processor we included in our system, the PC achieved a high CPU score of 4885. You will not need such a fast processor in your system, however. If you want to save some money, feel free to select a different CPU. We chose this fast processor so that we could also use our system for several video applications.

Our system also scored well in both the memory test (4230) and the hard drive tests (4398). We were not at all surprised by the high scores for Windows XP Startup, Application Loading, and other hard drive tests. This system does indeed load Windows and other programs very quickly.

Final Remarks

Overall, we really enjoyed putting together this system and didn't encounter any serious problems during the build process. Setting up and configuring the music receivers was equally easy. Even if you don't want to build a computer, you should be able to buy a couple of Squeezeboxes and quickly convert your current PC into a media server. RS

by Kylee Dickey

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Notebooks

Presario R3240US Athlon 64 3200+
15.4" WXGA TFT 512MB RAM 60GB
DVD±RW Wireless LAN WinXP Home
$1446.00

Aspire 1355LC Mobile AMD
15.0" TFT 512MB RAM 40GB HD
$929.00

VAIO TR3A Pentium M 1.0 GHz
10.6" TFT 512MB RAM 40GB HD
$1885.00

Networking

WGR614 54Mbps Cable/DSL
Wireless Router IEEE 802.11g
$59.99

AirPlus G DI-514 2.4GHz
4-Port 802.11g Wireless Router
$59.99

WRT54G 54Mbps Wireless G
Broadband Router
$66.99

Video Cards

GV-NX59128D nVidia
GeForce PCX 5900 128MB DDR
256-Bit PCI-Express x16
$214.00

ATI RX9800PRO 128MB DDR
256-Bit DVI/S-Video 8x AGP
$194.00

nVidia GeForce 6800 128MB DDR
256-Bit Model# 128-A8-N343-AX
$280.00

Hard Drives

250GB External Hard Drive
Dual-option Backup USB 2.0 &
FireWire Model# WDXB2500JBRNN
$242.00

250GB 7200RPM SATA 8MB
Buffer Model# 7Y250MO - OEM
$189.99

40GB 5400RPM Notebook HD
Model# MP0402H - OEM
$84.00

Cases

P-160WF Silver Aluminum
Performance 1 ATX Mid-Tower w/ Side
Window Panel & Front LED Display
$135.00

X-Infinity
ATX Mid-Tower
350W Power Supply
$75.00

668WBP
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Build A Video Server With Multiple Receiver Nodes

Master PC Theater

Build #34 Skill Level: 1 **2** 3 4 5 ***Apprentice***

After we built a music server that streamed music files to various stereo systems throughout the house for the previous article, we wondered if we could build a similar system that would stream video to several televisions in one home. The receivers we bought for our music server could only stream music, so although we could use the same PC again, we needed to find a different set of receivers that could receive video streams from the PC and transmit them to TV sets in the house.

Goal

Our primary goal was to build a system that could save video files on the hard drive and stream them over a network to a TV. We had few criteria for what the final system would look like, with one exception: that it have the ability to play different video streams over mutiple TV sets simultaneously. The key to making this happen was in selecting the right video receiver to connect to our PC. We hoped to find a system that was easy to use so that anyone could learn to cue up a favorite movie on a TV in our house without any difficulty or excessive training.

Background

Many companies manufacture devices that can stream video to a TV. Some of these include Linksys, with its Wireless-B Media Adapter, and Gateway, with its Wireless Connected DVD Player. We chose the SMC EZ-Stream Universal Wireless Multimedia Receiver, a device that can stream music files, Internet radio, still images, and video to a home entertainment system. From the product description, these receivers did everything we wanted them to, but most importantly, we found a great deal on these EZ-Stream receivers. We found them on sale for $150 apiece, which was already a good price, but there was also a $50 mail-in rebate on each receiver. After sending in our rebates, we got the two EZ-Stream receivers for less than $190.

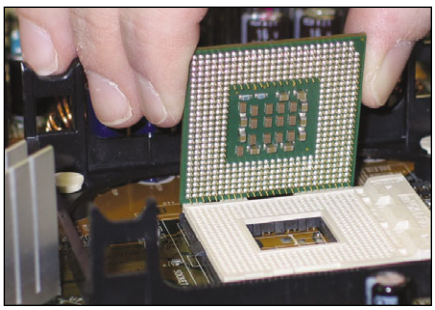
You can connect the EZ-Stream receivers to an existing PC, but we built our own video server. We'll describe how we built our system, but if you want to convert an existing PC to a video server, you can skip the build process and just connect and configure the video receivers.

We chose an ASUS P4R800-V Deluxe motherboard, which had all the components we really needed, including a SPDIF output, four Hi-Speed USB 2.0 ports, a FireWire port, and an RJ-45 Ethernet port. We felt that it was important to have both Hi-Speed USB and FireWire ports so that we could import home videos from a variety of digital camcorders.

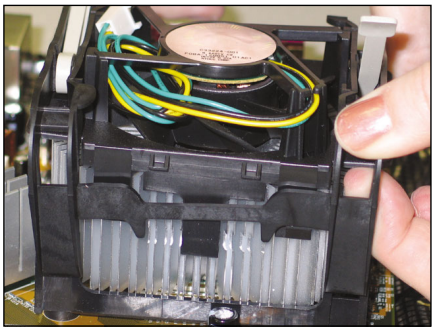
The motherboard includes a built-in sound card and a built-in video card. We could have bought a better sound card or a video card for our system, but we planned to listen to music and watch video on our entertainment system rather than the PC. The computer would simply serve as a storage point for our music and video files.

We used a 160GB 7,200rpm Samsung hard drive that we already had on hand, with the understanding that at some point in the future this system would really benefit from a hard drive upgrade. Ideally, we would have installed a 250GB drive to ensure plenty of storage space for space-consuming video files.

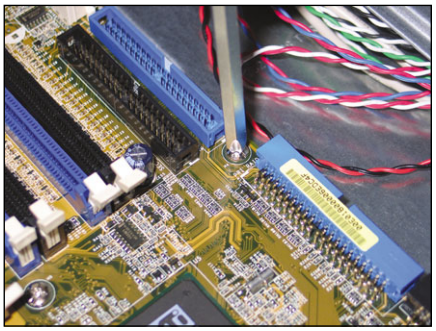
We could have built a prettier system, but we planned to keep the video server itself tucked away. After all, we would showcase the receivers, not the PC. Because of this, we saved money and bought an affordable APEX Mid-Tower Super Case. By saving some money on the enclosure, we could set some money aside for a hard drive upgrade later. The case has several



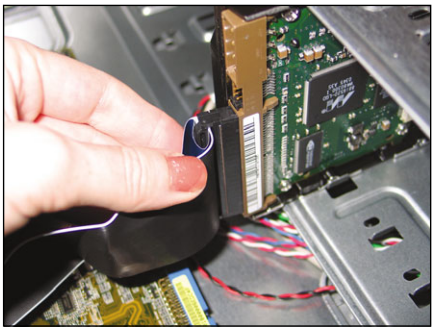
Before installing the motherboard in the case, we placed the processor in its socket on the motherboard. We were careful to line up the correct corners of the CPU and its socket.



We locked the Intel Pentium 4's stock fan into position.



We used the screws that came with the case to attach the motherboard to the standoffs.



We connected the loose end of the IDE cable to the back of the hard drive.

extra drive bays so that we can add more hard drives when our music and video files fill the existing drive.

We bought a Sony CD-RW/DVD-ROM combo drive at a very affordable price. It was essential to install a DVD drive so that we could copy videos to the hard drive. We did not buy a DVD-R/RW or other type of recordable DVD drive because our intent was not to make copies of movies but just to store them on the computer and play them back on the television.

We added a set of speakers to our system even though we planned to play music and video back over the TV and stereo equipment rather than over our PC speakers. We felt that it would be an asset to the system to be able to hear music and video files after ripping them to the computer's hard drive. We went with a good brand in choosing a decent set of 2.1-channel Altec Lansing speakers, but we didn't spend too much because these speakers wouldn't be part of the primary listening experience with our video server. We could have just as easily bought a cheaper set, or we could have left speakers off the system entirely if we planned to listen to music and videos only through the EZ-Stream receivers.

The Build

The APEX case opened very easily. We simply unscrewed the thumbscrews on the left side of the back of the case. Then we set the case on its right side and slid the left panel toward the back of the case and off.

Install the CPU and fan. First, we installed the processor and fan on the motherboard. To avoid damaging the motherboard, we set it on the antistatic bag from its original packaging. We were careful to line the CPU up with the socket properly because Intel Pentium 4 processors are notorious for having pins that bend out of position very easily. We positioned the processor over the socket and then let it drop gently into the socket. We pulled the lever next to the socket down to lock the CPU in place.

Our P4 came with a stock Intel heatsink, which we placed over the processor. Securing the heatsink in place was just a bit trickier because one of the

Parts List

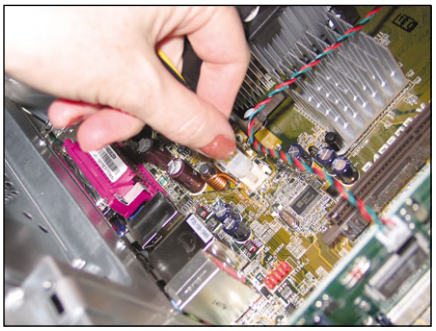
Model	Price	Notes	
Case	APEX Beige Mid-Tower Super Case (7C574-115)	$22	
Power Supply	350W	$0	Came with case.
Motherboard	ASUS P4R800-V Deluxe	$99	
Processor	Intel Pentium 4 3.2E GHz 800MHz FSB, 1MB L2 Cache, HyperThreading Technology (Retail)	$279	
Memory	Kingston PC3200 DDR400 512MB Kit	$106	
Video Card	ATI Radeon 9100 IGP 3D Graphics	$0	Built into motherboard.
Sound Card	AD1888 SoundMAX Six-Channel Audio	$0	Built into motherboard.
Network Cards	1xLAN port - Marvell GbE	$0	Built into motherboard.
Hard Drive	Samsung 160GB 7,200rpm IDE Hard Drive, Model SP1604N (OEM)	$93	
CD/DVD Drive(s)	Sony Beige 52X32X52X16 Combo Drive, Model CRX320E (OEM)	$43.99	
Monitor	N/A		
Keyboard	KBTEK MCK-600-02 Keyboard PS/2 107 Keys (OEM)	$5.49	
Mouse	Logitech SBF96 Optical Wheel Mouse PS/2 (OEM)	$9	
Audio Equipment	Altec Lansing 221 2.1 Speaker System	$39.99	
Other Hardware	Buy 2: SMC EZ-Stream Universal Wireless Multimedia Receiver (SMCWMR-AG); $142.99 each, less $50 rebate on each	$185.98	
	AUDIO 18-inch 2-Pin Connector CABLE-OEM (11A1-16424)	$1	
Software	Windows XP Home	$89	On sale. Clearing out SP1 before SP2 release.
Total		$973	

System Notes	
Physical Description	
Height	18.75 inches
Width	7.25 inches
Depth	16 inches
Weight	20.54 lbs.
Other Physical Details	Video receivers are each 6.38 inches high x 2.75 inches wide x 6.45 inches deep. Each receiver weighs 0.7 lbs.
Hits & Misses	
Outstanding Features	Supports up to 800MHz FSB, has a Wi-Fi slot for optional wireless LAN, RAID 0/1/0+1 and JBOD support, FireWire port, SPDIF-out port, Gigabit Ethernet, ASUS Q-Fan, AI Overclocking, ASUS C.P.R., adjustable FSB/DDR ratio, six Hi-Speed USB 2.0 ports, four SATA ports, and independently operating video receivers with custom remote controls.
Weak Links	This system's greatest weakness is that it supports only a few file formats. It can only play MPEG-1 and MPEG-2 video, and it can only play MP3 audio. We'd like to see a video receiver that can also handle MPEG-4, AVI, WMA, and AAC formats.
Performance	
3DMark03	764
PCMark04	4420

two plastic levers that lock the heatsink in place had come loose in shipping. It was barely attached to the heatsink's frame. Fortunately, we only had to apply a little bit of pressure to pop the lever back in place. We pulled the four clamps on the corners of the heatsink down so that they clasped the plastic bracket around the CPU socket.

Then we pulled each of the levers on the top of the fan down and into place. To finish the CPU and heatsink installation, we plugged the CPU fan's power connector into the proper slot, which was labeled FAN PWR on the motherboard.

We attached one of the IDE cables to the primary IDE slot. Note that the striped edge of the cable had to line up with Pin 1 of the IDE slot.

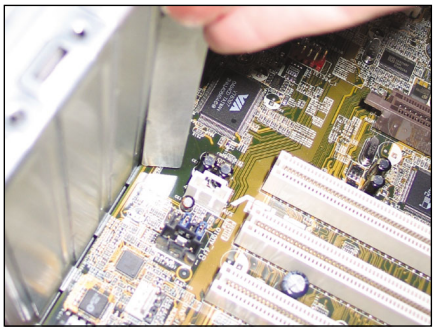


We also plugged in the 4-pin power connector.

Replace the backplate. Our case came with a standard backplate installed. However, our ASUS P4R800V Deluxe motherboard had many features and, not surprisingly, more ports than the case's backplate had port openings. We opened the case by unscrewing the thumbscrews on the back and then sliding the left-side panel back and off the case. We rested the case on its side and then removed the screws that attached the backplate to the case. We only needed to apply a little bit of pressure to remove the backplate. The new backplate that came with our motherboard simply snapped into place and did not require any screws. The new backplate had openings for four Hi-Speed USB 2.0 ports and a FireWire port.

Install the motherboard. We twisted several standoffs (which came with our case) into the inside of the case. We positioned each standoff under a screw hole on the motherboard. These standoffs would suspend the motherboard away from the case and protect it and its components from electrical charges or physical damage. We made sure that there was a standoff under any portion of the motherboard that might be heavy and likely to sag.

We tilted the motherboard to the side so that its ports entered the case first. We lined the ports up with the backplate and threaded them through the backplate openings. Once the ports were inserted through the backplate, we gently set the rest of the motherboard down. We lined the motherboard's screw holes up with the standoffs and connected the board to the standoffs.



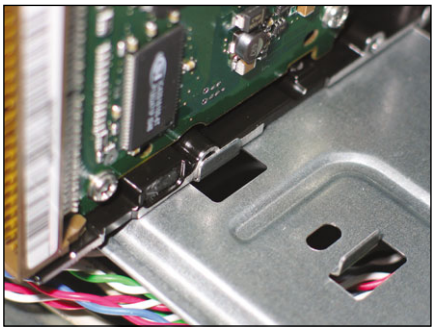
Several extension cards came with our motherboard. To make space for these, we removed the perforated port-opening covers from the back of the case by carefully pulling them loose.

Next, we found one of the IDE cables that came with the motherboard and inserted one end of it into the Primary IDE slot of the motherboard. We made sure that we lined the striped edge of the cable up with Pin 1 of the IDE slot.

Install the hard drive. Sometimes hard drive installation is difficult only because the drive bays are either hard to access or hard to remove. Luckily, our case made it easy to install the hard drive. Each of the drive bays was labeled, so we chose one that was labeled HDD. We didn't even have to remove the drive bay from the case. We just slid the hard drive from the inside of the case into the back of the drive bay. We only needed to secure the drive with two screws instead of four because some small support ledges supported the right side of the drive. We lined up the screw holes of the hard drive and of the drive bay and then tightened the drive in place.

We located the IDE cable that we had attached to the motherboard earlier. Once again, we checked to make sure the striped edge of the cable was lined up with Pin 1 of the IDE slot. Then we pressed the IDE cable into the slot on the back of the hard drive. We also took one of the power supply's connectors and attached it to the back of the hard drive.

Install the CD-RW/DVD-ROM combo drive. Once we had connected the primary drive (the hard drive), we were ready to connect the secondary drive, our CD-RW/DVD-ROM drive. Accessing the optical drive bay was a little bit more involved than accessing the hard drive bay.



It wasn't necessary to remove the right panel of the case to secure the hard drive. The bay's support ledges held the other side of the drive firmly into place.

We had to remove the top drive bay panel from the front of the case, but we also had to temporarily remove the drive bay panel beneath it, as well. We had to remove this second panel to make space for the drive to slide into the top bay. The panels simply popped off the front of the case.

We lined up the optical drive with the front of the top drive bay. Then we pushed it into the case from the front. We inserted the drive bay far enough that the front of the drive lined up flush with the front of the case. Then we used a pair of screws to secure the drive to the bay in the same way that we had connected the hard drive to its bay.

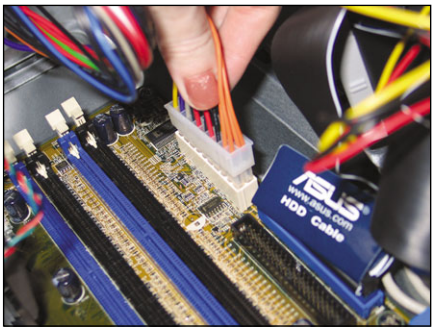
We found another IDE cable in our motherboard box and connected one end of it to the secondary IDE slot on the motherboard. Then we connected the other end of the cable to the back of the DVD drive. As before, we were careful to line the striped edge up with Pin 1 of the slot on the motherboard and on the DVD drive. We finished connecting the combo drive by attaching one of the power supply's power connectors to the back of the drive. Finally, we replaced the second drive bay panel that we'd removed by placing it over the bay and pressing it until it snapped into place.

Install the memory. The ASUS users manual indicated that we could install our Kingston PC3200 DDR SDRAM kit's modules in either the blue or the black DIMM slots. We chose the blue slots and inserted each of the Kingston memory modules into one of the blue DIMM slots on the motherboard. We pressed the memory down until the side levers of the DIMM slot popped up and locked in place around the ends of the memory modules.

Add backplate expansion pieces as desired. The ASUS P4R800V Deluxe motherboard came with a collection of useful expansion pieces. For instance, one piece would add digital-audio output with SPDIF and coaxial outputs. Another of the expansion pieces had a built-in game port and two extra Hi-Speed USB 2.0 ports. There was also a backplate with a serial port for connecting to older peripheral devices. There was only one of these pieces we didn't install. We skipped the game port/USB port expansion piece because our motherboard had only two spare USB headers, and our case had a pair of front USB ports. We felt that it would be more convenient to connect external hard drives, digital camcorders, MP3 players, or other devices at the front of the PC rather than at the back of the case. In addition, because this system would be a video server, we wanted the USB ports up front where we could access them easily to connect storage or peripheral devices that contained video and audio files. We followed the instructions on the APEX documentation to find the proper jumpers for the front USB connectors and then hooked them up.

To install each set of add-on ports, we removed a backplate for a PCI card. With this case, removing the backplates was as simple as pressing on the perforated metal until the backplate popped off of the case. We were a little bit concerned about damaging the motherboard with a piece of flying metal; we were careful to press from the inside of the case and to apply pressure gently and gradually until the backplates popped off the back of the case. We placed each expansion card so that its ports were visible through the now-exposed openings in the back of the case. Then we screwed the card's bracket to the back ledge of the case.

Connect the power supply. With our build almost completed, we plugged the largest of the power supply's connectors into the motherboard's power socket. Then we attached the power supply's 4-pin power connector to the 4-pin power socket located close to the processor and CPU fan. We slid the left panel back onto the case and twisted the two thumbscrews onto the back side of the case. We set the case upright and then connected our keyboard and mouse to the proper ports on the back of the PC. Although we did not include a monitor in the cost of building this system, we obviously still needed to connect a display to the PC. We had an extra LCD monitor, so we connected its data cable to the back of the monitor and to the monitor port on the back of the PC. Then we plugged the PC's power cord into the back of the computer and the LCD's power cord into the back of the monitor. Finally, we plugged both the computer and the monitor into open sockets on our surge protector and turned on our system.



As we neared the end of the build, we plugged the largest of the power supply's connectors to the power socket on the motherboard.

After we installed Windows, we still needed to install the drivers that came with our ASUS motherboard. This was important because some peripheral devices wouldn't work later unless we installed the drivers ASUS provided. We inserted the ASUS disc and followed the prompts to install any required software and drivers. Then, because we could connect our video server and video receivers using Ethernet cables, it was important that our system have all the latest security patches. We connected an Ethernet cable to the back of the PC and to our router. Then we ran Windows Update and installed all Critical Updates.

Finally, we inserted the installation disc that came with the EZ-Stream receivers. We followed the on-screen instructions to install the SMC Media Server and then restarted the computer. We launched the SMC Media Server and clicked the Shared Folders tab. This is where we could indi-

cate which files we wanted the video server to share and make available for streaming. In the left pane of the window, browse to a folder that contains the media files you want to use and then click the Add button. We clicked the Internet Radio tab to add the URL of the Internet radio stations we wanted to play using our EZ-Stream devices. Finally, we clicked the Update tab and clicked the Update button. This told the software that we were done making changes to the content of our media folders and Internet radio links. The software scanned these resources and updated its own index of our music and videos. Under the Update tab, we also had the option to schedule automatic updates.

Set up the video receivers. It was fairly easy to set up the SMC video receivers. The EZ-Stream device only supports Composite RCA cables. Other companies make devices that support higher-quality connections, so if you'd rather use S-Video, you can still build a video server, but you'll want to find different video receivers for your system.

To set up the first receiver, we connected the RCA audio and video cables to the proper ports on the back of the device. The two audio connectors and the video connector were all color-coded, so it was easy to connect the receiver. Next, we connected the loose yellow RCA connector to the video-in port of our TV. We then attached the red and white connectors to the corresponding audio-in ports on our stereo receiver. If you do not use a stereo receiver but only a TV, simply plug the red and white connectors into the audio-in ports of your TV.

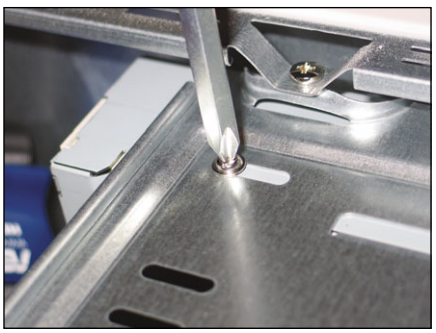
Next, we plugged the receiver into the power supply and turned on the TV and stereo. We had implemented our router's MAC (Media Access Control) filtering option to prevent unauthorized users from accessing our network. We needed to turn this feature off temporarily so the router would allow the EZ-Stream receiver on our network.

We inserted the two AA batteries in the SMC remote control and pressed the remote's power button to start the EZ-Stream receiver. Menus and messages appear on the TV screen. These on-screen messages walked us through the rest of the setup. We used the SMC remote control to answer the guided questions.

First, we chose Use Wireless 802.11 when prompted to choose a network interface. Then, we had to enter the SSID (Service Set Identifier) for the wireless network. The setup wizard asked if encryption was enabled. We did not have encryption enabled, but if we had had WEP (Wired Equivalent Privacy) enabled, the software would have prompted us to use the remote to enter the 32-character hex code.

Next, the on-screen setup guide asked us to indicate what type of network we were using. We chose Infrastructure, as SMC's documentation instructed us to do to indicate that we were using either a WAP (Wireless Application Protocol) or wireless router. Next, the system asked if we had a DHCP (Dynamic Host Configuration Protocol) server present. We chose Yes and let the SMC receiver obtain an IP address. We followed the rest of the on-screen instructions and, when prompted, let the receiver download and install updated firmware.

We followed all of the same procedures to connect the second video receiver. Finally, we returned to the configuration tools for our router and scanned for connected devices. Here we saw the familiar MAC addresses for our video server and for any other connected devices. We also saw a pair of new MAC addresses. These were our SMC video receivers. We wrote the MAC addresses down, entered them as approved MAC addresses, and then turned MAC filtering back on.



Next, we used a pair of screws (included with the combo drive) to attach the optical drive to the appropriate 5.25-inch drive bay.

Testing

Overall, our video server and the connected SMC EZ-Stream receivers worked very well. The setup and configuration were relatively straightforward, and we didn't have any trouble adding audio and video files to our media folder. The SMC receivers can read ID3 tags, so we could view track information in the on-screen menus. The menus appeared on the TV screen and were simple to use because they were sorted by Album, All Songs, Artist, Genre, or PlayList in a hierarchical, easy-to-navigate order.

Video played very well, and we were pleasantly surprised that there was no lag due to interrupted wireless data transmission. If you do experience any delays, lags, or stutters, though, you could connect the SMC receivers with an Ethernet cable rather than wirelessly.

We also ran the 3DMark03 and PCMark04 benchmarks on our system, and it performed very well. We weren't surprised because applications and files loaded quickly on our system, and programs seemed to run very efficiently. You can see the benchmark results in the "Parts List" chart.

Our video server had one major fault, however. The SMC EZ-Stream receivers supported only a few file types. They can only decode MPEG-1 and MPEG-2 video, so we couldn't watch any MPEG-4, AVI, or other video files. The receivers also could only play audio in MP3 format, so none of our WMA or AAC files played on our system.

Final Remarks

Overall, this was a very affordable and simple way to set up a video server. We didn't have any trouble building the PC, setting up the receivers, or configuring the system. However, file support was really an issue with this system. If we had it to do over again, we would seriously consider buying a set of video receivers that supported a wider range of video and audio formats. RS

by Kylee Dickey

Build A Wired Ethernet Network

Supercharge It With Gigabit Speed

Build #35 Skill Level: 1 2 **3** 4 5 ***Journeyman***

Looking for a way to avoid trudging up to the accounting office every time you want to take a gander at that Excel file? Maybe you just invested in broadband Internet access and you'd like to share the connection among your office computers. With a wired Ethernet network, these tasks have never been easier.

For the gamer in all of us, who could forget his first LAN party? Before broadband Internet access became widespread, makeshift menageries of hubs, switches, and a tangled spectrum of CAT 5 cables comprised a rudimentary network for multiplayer gaming.

Affordable wireless networks have displaced a lot of wired networks, but the emergence of Gigabit speeds for wired networks has breathed new life into an old classic. We'll show you what you need to build a cutting-edge wired Ethernet network that can harness these fast Gigabit speeds.

Goal

We wanted to build a wired Ethernet network for half a dozen desktop PCs. Assuming our PCs were built and waiting to be linked together, we focused on purchasing NICs, a switch, and a router to direct Internet traffic and serve as a firewall for our network. We didn't have a target budget, but we guessed the entire setup would cost about $400.

Background

We've already hinted that there are still a few good reasons to set up a wired network instead of a wireless network. Wired networking hardware is generally much cheaper than wireless alternatives. You can purchase a basic router and NICs to share an Internet connection and set up an entire network for about the cost of a single wireless NIC; in fact, so many motherboards have an integrated LAN feature that you may only need to purchase a router.

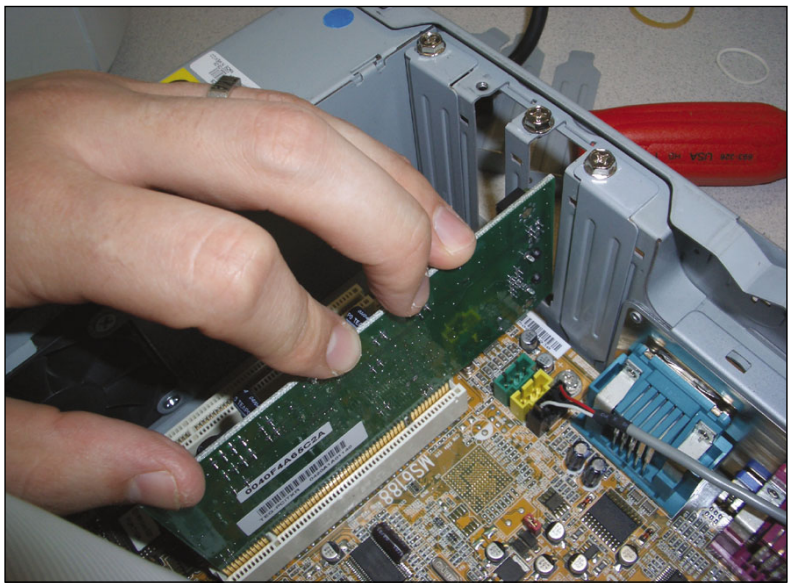
Security is another advantage of wired networks. A wired network connected to the Internet will face the same threats as wireless networks, but wireless networks also have to deal with a host of other bad guys. With a wired network, you won't have to worry about packet sniffers, wardrivers, or that strange guy in apartment 11B taking advantage of the inherent security weaknesses in wireless networks.

Devices that act as the base of a network typically fall into three groups: hubs, switches, and routers. Hubs are usually the least expensive but also the simplest of the three. They act as convergence points in a network, sending data to and from devices connected to it with Ethernet cable.

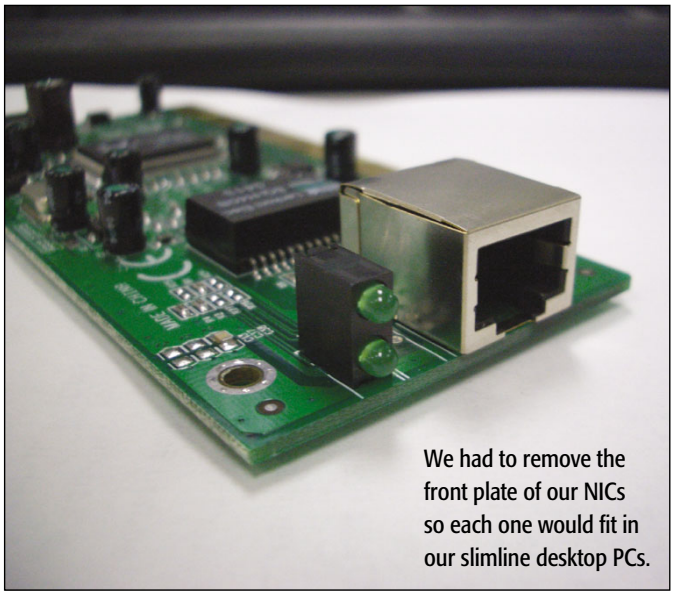
Switches, on the other hand, go one step further. Once data arrives at a hub, a switch will determine how and where to send the data. Switches help facilitate more efficient data transfers.

Routers are able to direct traffic between two or more networks and also direct Internet traffic, allowing several different devices to share an Internet connection (because the Internet itself is a giant network). Most routers come equipped with security features to enhance your network's safety while you are exposed to the Internet. A firewall and NAT (Network Address Translation) are two common features that are standard on most routers. NAT uses a single public IP address (your network's location on the Internet) but recognizes each networked device's local IP address (the device's location on the network). This serves two purposes: It lets multiple PCs access the Internet with only one connection and hides your networked computers' locations from the prying public.

NAT is good for basic security, but a dedicated hacker can crack it. Firewalls enhance security in several ways. They will block unwanted data from your network and should similarly alert you when a program on your computer tries to send data out to the Internet without your permission. A good firewall can also put your networked PCs in stealth mode, which hides your network's public IP address from potential hackers trying to probe your network for weaknesses.



It doesn't take too much pressure to push each NIC into an open PCI slot.



We had to remove the front plate of our NICs so each one would fit in our slimline desktop PCs.

All-in-one devices. Even though hubs, switches, and routers perform different tasks, all-in-one devices that incorporate all three are commonplace today. For a basic network, an all-in-one will be your best solution. If you have peripheral devices, such as a printer or a Web cam, that you'd like to add to your network, an inexpensive hub can accomplish the task without the need for an additional switch or router.

If you're willing to fork over a few extra dollars (which we were), you can have a wired network with blistering fast transfer rates that wireless networks can only dream of. The old networking hardware that you're probably familiar with transferred data at 10Mbps and 100Mbps. A switch with a 1Gbps transfer rate can theoretically transfer data about 10 times faster than the fastest wireless networks. In fact, wireless networks are only now theoretically achieving throughput comparable to old 10/100Mbps networking hardware.

There are a few reasons you may want to use older 10/100 equipment. With commercial broadband Internet speeds topping out at about 3.5Mbps, you can use 10/100 hardware if you want a simple network that shares an Internet connection and save some cash. You'd see a bigger difference if you use Gigabit Ethernet with a T1 Internet connection, but this type of connection costs several hundred dollars per month.

Your PC's own hardware is probably another limiting factor when it comes to Gigabit Ethernet. Older hard drives may not have data transfer rates that can keep up with Gigabit speeds, and the PCI slots that you'd probably use for the Ethernet adapters are 32-bit and share a maximum throughput of 133MBps. If you have PCI cards in other slots, it will slow down your throughput. Motherboards with 64-bit PCI or PCI-X slots will support Gigabit speeds, but these are rare. A number of motherboard manufacturers are integrating Gigabit Ethernet adapters onto their motherboards. This method achieves higher data transfer rates than a Gigabit NIC using a PCI slot, but buying each computer a new motherboard for the sole purpose of networking them together is a costly, if not ludicrous, proposition.

Despite these practical limitations, Gigabit Ethernet is still much faster than 10/100 or wireless networks. If you regularly send massive files over your network or just want bragging rights among your friends, Gigabit Ethernet is the way to go.

Our parts. We used SMC's 1Gbps Gigabit Ethernet eight-port switch as the backbone for our network and purchased six Gigabit Ethernet PCI adapters from Trendware (one for each of our PCs). Similar switches and adapters exist from other manufacturers; personal preference plays a large role in the particular switch and adapters you choose to buy. You may also want to check your motherboard's system specs, as a number of new boards sport integrated Gigabit LAN adapters. We used some extra Ethernet cable we had lying around, but you'll want to figure that expense into your budget. If you decide to go Gigabit, you must buy CAT

Watch Out

Despite the relatively minimal amount of effort it took to install an Ethernet adapter, our hubris got the better of us. When we ordered the NICs, we forgot our six workstations had slimline, low profile desktop cases and required specially sized PCI Ethernet adapters. We had to leave the case off and unscrew the mounting plate on each NIC to install the NICs in the motherboards' PCI slots. Our setup scored fairly high marks on our ugliness benchmarks, but it would serve our purposes of networking six computers together. You'll want to purchase adapters that fit comfortably in your case.

Our NIC mini-debacle reminded us to stress the importance of preplanning your wired network. Walls, floors, and other objects are a larger concern for a wired network because it can mean physically altering your home or office to run Ethernet cable. If you have computers in remote locations, stringing Ethernet cable up stairs and through doorways is an expensive proposition, not to mention a safety hazard. It might be a better idea to use a wireless network. But if you still prefer a wired network, take careful measurements before drilling holes and buying Ethernet cables. ▲

Parts List

Component	Model	Price	Notes
Switch	SMC eight-port SMC8508T 10/100/1000 Gigabit Switch	$149.27	After $40 mail-in rebate
Router	Edimax Broadband Router, 1 WAN + 4 Switching Port + 1 Port Print Server	$41.99	Included with case
Network Interface Cards	Trendware TEG-PCITXR 32-Bit 10/100/1000Mbps Gigabit PCI Adapter	$126	Six used ($21 each)
Total		**$317.26**	

5e cable, which can support such speeds. It's a little pricier, but you can save money if you know how to attach the connectors yourself.

We used an EDIMAX router to connect our network to the Internet and act as a basic firewall. We liked this particular router because it sports an integrated print server in addition to being a router. A dedicated print server (either integrated or standalone) can be a boon to your network, especially if you're planning on a lot of heavy-duty printing. You can share a printer with Windows 95/98/Me/2000/XP, but you must keep the computer that you have your printer connected to powered on whenever another networked computer needs to print. Also, the performance decreases on this computer when multiple print jobs are in progress. A dedicated printer eliminates these inconveniences. Choose a print server based on the type of connection your printer uses (parallel or USB).

The Build

Provided you don't weave a giant human spider web with your Ethernet cables, setting up your network is fairly straightforward and not too messy. You'll spend just as much time (if not more) configuring your network settings as actually installing the hardware components. Because you'll be opening your PCs and exposing your hardware, we also recommend you try to avoid appearances from your PC's mortal enemy—static electricity—by working in an uncarpeted area or on a hard, plastic floor mat and wearing an antistatic electricity wristband.

We installed our first NIC and repeated the process for our other PCs. We shut down and unplugged our computer and removed the top of its case. We removed the front plate from the NIC (see the "Watch Out" sidebar) and pressed the NIC firmly into the PCI slot.

After our NICs were snugly nestled in their PCI slots, we restarted each computer, and WinXP automatically detected our new hardware. At the Found New Hardware menu, we inserted the included floppy disk. We clicked Install From A List Or Specific Location and Next. We clicked Search For The Best Driver In These Locations and clicked Include These Locations. We typed **A:\winxp** in the empty field and clicked OK.

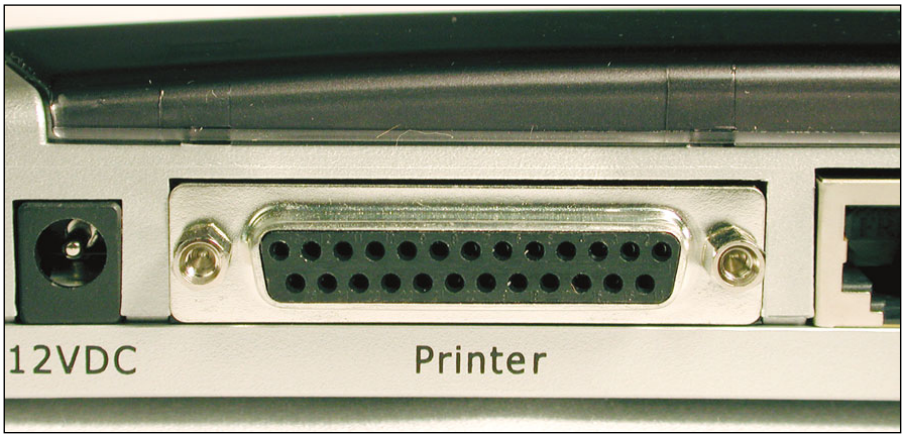
We were a little disconcerted that WinXP identified our NICs as Realtek RTL 8169/8110 Family Gigabit Ethernet Adapters because our cards were from Trendware. Turns out Realtek RTL 8169/8110 refers to the adapter's switch controller. We hoped that we wouldn't run into any snags with data transfer speeds as WinXP indicated the adapters were Gigabit Ethernet adapters. Although WinXP warned us that the Ethernet adapters had not passed Windows logo certification, Trendware's users manual assured us this wouldn't be a problem. We clicked Continue Anyway and clicked Finish to complete the installation.

We shut down each PC and connected CAT 5e cable from each NIC to an open port on our switch. To share an Internet connection among our six PCs, we connected the Ethernet cable included with our router to an open port on our switch. Remember, cable and DSL speeds top out far below Gigabit speeds, so you won't need CAT 5e cable when you connect a router to the switch. While we plugged our office's Ethernet cable with Internet access into the WAN port of our router, you should run an Ethernet cable from

Powerline Networking

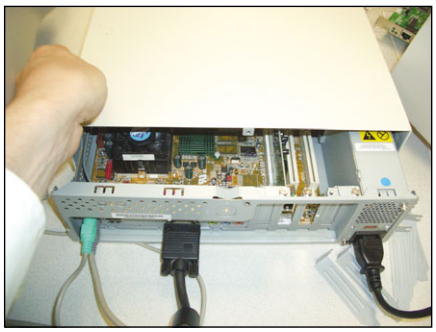
Supplying both a unique alternative to a wired Ethernet network and a cheap pun, powerline networks take plug and play to a literal extreme. A powerline network consists of special adapters and uses your home's existing electrical outlets to link your PCs together. A group of manufacturers formed the HomePlug Alliance (www.homeplug.org) to standardize powerline networking hardware.

Setting up a powerline network is as simple as plugging an adapter into an electrical outlet and running either a USB or Ethernet cable to your computer. A powerline network can spare you the expense and hassle of stringing hundreds of feet of Ethernet cable around your house, but it does have a few drawbacks. You'll still need a router if you want your PCs to share an Internet connection. Powerline technology currently has a theoretical speed limit of 14Mbps, which lags behind some wireless networks and can't even touch the blazing Gigabit speeds wired networks can achieve. Also, many homes have two major power circuits running into them; powerline networks use a common circuit. It's conceivable that two outlets in the same room may not support a powerline network. Although these networks are becoming a novelty, it's still a fun networking experience if you have some extra cash. ▲



Although we really like the idea of an integrated print server, we should have purchased a model with a USB port instead of this parallel port.

CAT 5 cable is no exception; if you're going Gigabit, all of your networking equipment must to able to handle the speed.



Look for an open PCI slot when you open your PC's case.

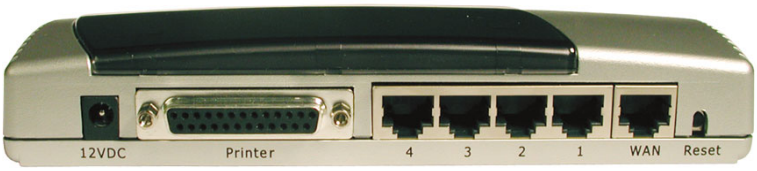
your DSL or cable modem to the WAN port. This completed the physical build. Green lights appeared on the front of the switch indicating Port 1 was operating at 100Mbps and Ports 2 through 7 were operating at 1,000Mbps. This showed us our router was working at 100Mbps and our Gigabit Ethernet adapters were working at their advertised speeds.

We even had an extra port on our switch if we wanted to set up a file server for our network. Check out "RAID 0+1 Under ~~$1,000~~ $1,100" on page 100 for a good start on building such a system and "Best Heavy-Duty Server For Under $2,000" on page 40 for an option on using it as a file server.

Up and running. With WinXP's Networking Wizard, experienced builders can have a small network up and running in about the time it takes to microwave a frozen TV dinner. Networking newbies may need a little more time, but the process has become more streamlined over the years.

System Notes

Router	Four 10/100Mbps switch ports, one 10/100Mbps WAN port, Integrated Print Server (Parallel), Anti-Denial of Service Stateful Packet Inspection Firewall, NAT, and Virtual VPN passthrough
NIC	10/100/1000Mbps, Interface: 32-bit PCI 2.2, Wake-on LAN
Switch	Eight 10/100/1000Mbps switch ports, supports jumbo packets up to 9Kb/packet, broadcast storm control, and CRC Filtering



Even most consumer-grade routers let you connect additional switches to the ports if you have more computers than ports.

In WinXP, we clicked Start and My Network Places. We clicked Set Up A Home Or Small Office Network, which is under Network Tasks. We clicked Next twice, clicked This Computer Connects To The Internet Through Another Computer On My Network Or Through A Residential Gateway, and then clicked Next again. We clicked Let Me Choose Connections To My Network and Next twice. To keep things simple, we typed **Workstation 1** in the Computer Description field and **ONE** in the Computer Name field.

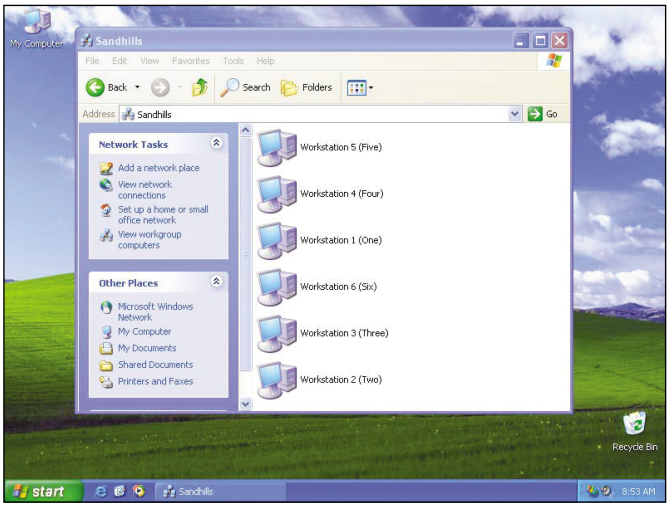
We clicked Next, typed **Sandhills** as our Workgroup Name, and clicked Next. We looked over our settings and clicked Next. Once the Wizard had configured our computer, it prompted us to create a disk with our network settings. You'll only need to do this if some of the PCs you're networking use Win9x/Me/2000. Instead we clicked Just Finish The Wizard; I Don't Need To Run the Wizard On Other Computers, Next, and Finish. We repeated the process for the five remaining PCs.

When you run WinXP's Networking Wizard, be careful that your workgroup name is identical for every computer. You'll know you've made a mistake if you click View Workgroup Computers and a workstation is missing.

Sharing files. Providing all of your PCs have been correctly networked together, it's easy to share files over the network. For starters, WinXP has a generic folder for shared documents conveniently named Shared Documents. To share this folder, we right-clicked it and clicked Sharing And Security. We clicked the Share This Folder On The Network checkbox, Apply, and OK. A small, open-palmed hand appeared under the Shared Documents folder icon, indicating we were sharing this folder on the network. If you'd rather not use the Shared Documents folder, it's just as easy to share other folders on your network using the same process with a different folder.

You can easily open a file on another workstation using this method. We clicked Start, My Network Places, and View Workgroup Computers. We double-clicked the workstation we wanted, opened its Shared Documents folder, and opened the file. It seems obvious, but simply opening a shared file on a networked PC won't work if you don't have the application that created it on your PC. To transfer a copy of a shared file, we simply dragged the icon from the networked PC onto our Desktop.

Security. If you're networking PCs without Internet access, your network is essentially secure. On the other hand, you could potentially threaten every system on your network even if only one computer is connected to the Internet.



You'll know you've set up your network properly when you can see each of your computers in the workgroup.

Green LEDs on the front of the switch indicate an active link and if the link is 10/100 or Gigabit.

We used our EDIMAX router to show you some common weapons most routers have in their arsenal to combat outside threats.

To enable our router's security features, we opened Internet Explorer and typed **192.168.2.1** in the Address field. This is the router's default local IP address, and typing it into the Address field launches the router's Web-based configuration utility. While Web-based configuration utilities are the most popular, your router may use a different method.

When the configuration utility prompted us for a password, we clicked LOGIN; there is no default password. We clicked General Setup, Firewall, Enable, and Apply. The EDIMAX router had a number of firewall features already enabled, including protection from the following types of attacks: IP Spoofing, Land Attack, Ping of Death, IP with zero length, Smurf Attack, UDP port loopback, Snork Attack, TCP null scan, and TCP SYN flooding.

We maximized our protection by clicking the checkboxes next to SPI And Anti-DoS Firewall Protection, RIP Defect, and Discard Ping To WAN Port. Discard Ping To WAN is particularly useful because it prevents hackers from discovering your router's public IP address. If you scroll down further in the window, you can enter an email address where you'd like alert warnings to be sent in the event the router detects an attack.

Testing

There's not too much to test on a network except for data transfer rates. We put our network on the track by sending a 400MB folder of assorted files from one computer to another. Our initial run left a "just drank a glass of lemon juice" sour taste in our mouths. It took 55 seconds to transfer the folder, which is about 58Mbps. Despite this woeful result, we weren't too surprised. The PCs we used in our network were near-fossilized 667MHz Pentium IIIs with hamster-powered 10GB 5,400rpm hard drives. Even though our switch indicated a Gigabit connection, our other hardware was likely creating a bottleneck effect.

To test this theory, we used the SMC switch and networked two other PCs hot off the *PC Builder* assembly line: our high-end Intel-based system and our digital media converter system. This time, we sent a 1GB video file over our network and were happy to see our data transfer rate skyrocket to 294Mbps. Although our network was still only around 30% efficient, we considered it a victory. In reality, the times you'll send 1GB of data over a small network are few and far between.

Final Remarks

Once we used PCs with a little more muscle, the strength of the Gigabit network showed. We loved the fast data transfer rates, but you'll want to consider your networking needs and your computers' limitations before buying a Gigabit switch. As a general rule of thumb, simpler networking tasks require simpler networking hardware. If you simply want to share an Internet connection and small files, such as Word or Excel documents, it's silly to buy a Gigabit switch and NICs when an all-in-one 10/100 router will do the trick. You'll still need to have Ethernet adapters, but integrated LAN is virtually standard on new PCs.

While we thought the integrated print server on our router would come in handy, we couldn't locate a printer in-house that used a parallel port connection. If you think something like an integrated print server would be handy for your network, buy a router with a printer port that matches your printer.

In general, networking is a skill that's easy to learn but difficult to master. But with technological advances pushing prices lower and lower, you can have a swift, simple network that won't take a bite out of your bottom line. RS

by Vince Cogley

Build A Wireless Network

Free Yourself From Ethernet Cables

Build #36 Skill Level: 1 2 **3** 4 5 ***Journeyman***

When it comes to aesthetics, wires aren't exactly a network's best friend. If you've ever waded through a floor of CAT 5 spaghetti, you know what we're talking about.

Wires can also be a nightmare for anyone who wants to network computers that aren't reasonably close to each other. Drilling holes in walls and uprooting carpet to hide intrusive cables can become an expensive and time-consuming undertaking.

Within the past few years, however, wireless networks have become an affordable solution to escape the physical restrictions of a wired network. Wireless technology has quickly matured and has even spawned its own jargon. In this article we'll show you how to enjoy the freedom of a wireless network and say "Adios!" to your wired network forever.

Goal

For our wireless network, we wanted a setup that included two desktop PCs and a laptop. The desktop systems would simulate two stationary PCs while the laptop would act as a mobile user roaming to and from different spots within the network.

Aside from actually installing the necessary hardware and networking the systems together, we had two additional, equally important goals. We sought to make our network as secure as possible and test how far our network would reach without greatly compromising signal strength or data transfer rates.

Background

While each new generation of wireless networking hardware is becoming easier to install, the process is still more involved than plugging a few Ethernet cables into the back of a router. You can also expect to pay a premium for wireless equipment.

Learning a little wireless lingo can greatly simplify the search for the right wireless network. For starters, wireless networks operate on the 802.11 standard established by the IEEE. 802.11a, 802.11b, and 802.11g are the three most common standards beneath the 802.11 umbrella.

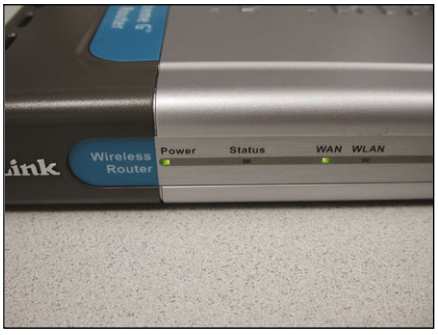
802.11b, or Wi-Fi, was the first popular wireless standard. It operates at the 2.4GHz frequency and can achieve a theoretical data transfer speed of 11Mbps. 11Mbps will handle broadband Internet connections with ease, but it gets left in the dust compared to swifter 802.11a and 802.11g devices. But prices for 802.11b equipment have dropped, making it an enticing option for someone who doesn't want to plunk down extra cash for 802.11a/g.

Some hailed 802.11a the successor to the wireless throne. With potential speeds of 54Mbps, 802.11a trounces Wi-Fi in terms of transferring data. It also has the benefit of operating at the 5GHz band, avoiding interference from devices such as cordless phones, microwave ovens, and other wireless networks that use the 2.4GHz frequency. Despite these improvements, 802.11a was fairly expensive and not backward-compatible with Wi-Fi; it never really found favor with the consumer market.

On the other hand, 802.11g appears poised to become the next standard in wireless networking. It uses the 2.4GHz band and is compatible with older 802.11b devices but matches 802.11a's 54Mbps speed. A lot of manufacturers are making products with "turbo" modes to burn even more rubber on the track. These new upstarts boast theoretical speeds of more

We attached the antennae to our PCI adapters once we installed them in their respective PCI slots.

LEDs on the D-Link router's front help you know it is powered on and connecting to both the Internet (WAN LED) and your networked computers (WLAN LED).



We plugged CAT 5 cable with an active Internet connection into the D-Link router's WAN port to give our workstations Internet access.

than 100Mbps. If you buy a router with some type of "turbo" technology, you may have to buy your adapters from the same manufacturer to harness the extra juice.

We mapped out our security plan before we configured the router and adapters. Strong wireless security is as vital to a good wireless network as the hardware itself. Without security, routers and access points behave similarly to radio stations: Anyone with the proper receiver/adapter within broadcast range can use the signal to his advantage. If you broadcast a vulnerable signal, potential threats range from someone using your Internet access for free to hacking the computers on your network. We would configure a router to use 128-bit WEP (Wired Equivalency Protection). Your data transfer rates will take a hit when WEP is enabled, but the added security is worth a drop in performance.

Browsing for components. We were treated to a veritable wireless buffet when we went browsing for our network components. The number of devices with different features was staggering. Because we anticipated building our network from scratch, we began our search looking for an all-in-one router/switch/access point. The router would direct Internet traffic while the access point would broadcast a signal to our networked computers. Four wired ports provided the flexibility to add wired components in the future. If you already have an existing wired network, you could opt for a single access point (see "Build A Combination Wired & Wireless Network" on page 157).

When it comes to wireless hardware with turbo technology, a plethora of companies claim they've built the best mousetrap. Linksys, D-Link, Buffalo Technology, Netgear, and a host of others have jumped into the fray claiming data transfer rates, or throughput, of up to 125Mbps. Remember,

Bling Bling

OK, we admit it. A souped-up network doesn't get us as wound up as a monster overclock or killer case mod. That doesn't mean you can't build a wireless network with enough gadgets to make Batman envious. It's so easy you won't even need a stodgy butler to help.

Start with the router itself. Beef up that scrawny factory antenna with an amplified antenna. An antenna's performance is usually measured in dB (decibels) or dBi (decibels, isotropic). An antenna with a high dB/dBi reaches farther with better signal quality than stock antennae. Amplified antennae are either directional or omnidirectional and range from a little more than $20 to several hundred dollars. With an outdoor antenna, you can finally network your beach hut laptop.

Several manufacturers including SMC, D-Link, Buffalo, and Hawking make amplified antennae. Make sure your router will accept the new antenna and that you have a boosted PC Card or PCI adapter (these must be boosted to send a signal back to the router). Just remember, if you can benefit from the increased range, piggybackers and wardrivers will be licking their chops to do so, as well. Placing your router at the center of your network will help, but strong wireless security is imperative with an amplified antenna.

We Repeat

Buying a repeater is another way to boost your range without purchasing a boosted adapter. A repeater captures a wireless signal and rebroadcasts it; repeaters work a lot like access points but don't need to be wired to your router to function. So why would you want to buy an amplified antenna if you could string a chain of repeaters halfway across town? Well, your performance deteriorates by about 50% for every repeater you have in the chain. Stick to one repeater in your network.

Gamers no longer need to worry about keeping their Xbox or PlayStation 2 near their broadband modem for an online fragathon; wireless game adapters let you incorporate your Xbox or PS2 into a wireless network. Both Wi-Fi and 802.11g game adapters exist, but 54Mbps speeds will be wasted on online gaming. Microsoft's Xbox Wireless Adapter is designed specifically for the Xbox, but you can purchase a cheaper alternative such as the Linksys Wireless-B Game Adapter that will work with either the Xbox or PlayStation 2.

Share A Printer

Although you can share a printer without a separate hardware device, this method has a few disadvantages. The biggest problem is that the computer to which the printer is connected must remain on for networked users to print. If the computer is in use, print jobs from other PCs will also take longer.

Buying a separate wireless print server can quash these problems faster than you can say "pages per minute." A wireless print server attaches to your printer so you'll no longer need to keep one of your networked PCs powered on to share a printer. Many manufacturers have incorporated print servers into their routers to create an even more all-encompassing device, but standalone models exist if you simply want to add one to your existing wireless network. If you choose to buy a print server, make sure its connector accepts your particular printer cable (usually parallel or USB).

If you have several desktop PCs that don't need to be simultaneously networked, a USB wireless adapter will tackle the problem in seconds. Berate your friends as you connect to a wireless network in seconds while they're still opening their cases to access a spare PCI slot. You can find USB wireless adapters from a variety of manufacturers at a price that is on par with PCI adapters.

With these accessories and the growth of media center PCs and WiMAX (Worldwide Interoperability for Microwave Access; also 802.16), it won't be long before you can play games, stream online movies, watch television, or surf the 'Net from the comfort of your Barcalounger. Take that, Bruce Wayne. ▲

The PC Card adapter easily slides into a laptop computer.

Be careful that you don't apply too much pressure when you install the PCI adapters.

We had to remove the antennae and switch front shields to accommodate our low-profile desktop workstations.

this speed in a wireless network is tantalizing, but network overhead, signal interference, and encrypted signals all take a bite out of your throughput. Although we chose D-Link's Airplus Xtreme G wireless router because we've had success with its products in the past, you'll find that there's no clear leader. Setting up a wireless network involves the same essential steps no matter what hardware you buy. For your money, we suggest selecting a brand you trust.

After we selected our router, choosing adapters was a relatively simple chore. We selected D-Link's Airplus Xtreme G wireless PC Card for our notebook and two Airplus Xtreme G wireless PCI adapters for our desktop systems. We picked these adapters because we hoped their turbo technology compatibility would satisfy our thirst for speed. If you're starting your wireless network from scratch, we don't recommend mixing 802.11b and 802.11g hardware unless you plan on upgrading your entire network to 802.11g in the future; the devices will be able to communicate with each other, but the faster 802.11g devices will be relegated to slower speeds in a mixed environment.

The Build

As much as we wanted to add a little dramatic flair to this project by cutting up old Ethernet cables, we restrained ourselves and focused on the task at hand. Setting up one desktop PC near the router gives you the option to use a wireless signal or Ethernet cable to connect to the router. This can come in handy during occasional instances when the router drops its signal.

We positioned the D-Link router in the geographical center of our network, which has two advantages: We optimized our coverage area and kept our signal from leaking too far away. This let us drift around our network with our notebook computer without losing too much signal strength and limited an unwanted third party's ability to sneak into our network (we'll deal with wireless security a little later). Also, try to position your network away from cordless phones and microwaves to avoid signal interference.

We started our wireless brouhaha by setting up the D-Link router. We connected the power adapter to the receptor on the back. We plugged in the adapter, and the Power LED indicated the router was powered properly. Next, we connected a CAT 5 cable with an active Internet connection into the WAN port of the D-Link (this might be labeled Internet, Uplink, or something similar on other routers). We ran another CAT 5 cable from LAN port 1 to the NIC (Network Interface Card) in one of our desktop PCs and restarted our computer. If you're using a cable or DSL modem, connect the modem to the WAN port with CAT 5 cable.

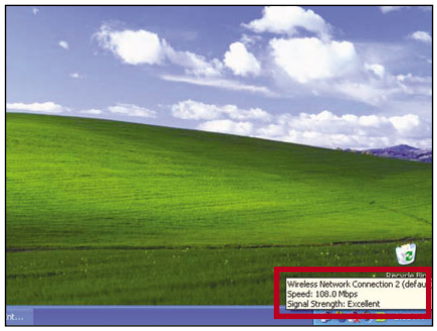
After we restarted our computer, we configured the D-Link router itself. We opened Internet Explorer, entered

System Notes

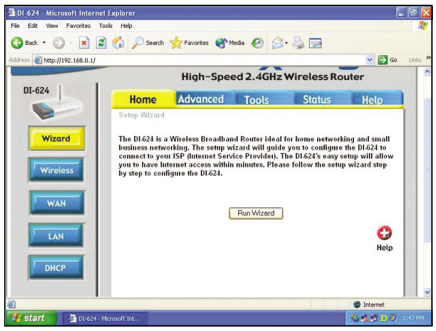
Router	IEEE 802.11g (108Mbps), four 10/100 Switch Ports, one 10/100 WAN Port, NAT, MAC/IP/URL Filtering, 64/128-bit Encryption, WPA-PSK (Wi-Fi Protected Access-Pre-Shared Key)
PC Card Adapter	IEEE 802.11g, Interface: PCMCIA, Transmitted Power: 15dBm, ±2dB
PCI Adapter	IEEE 802.11g, Interface: 32-bit PCI 2.2, Transmitted Power: 15dBm, ±2dB

Parts List

Component	Model	Price	Notes
Router	D-Link AirPlus Xtreme G series High-Speed 108Mbps 2.4GHz Four-Port Wireless Router	$85	
Network Interface Cards (PC Card)	D-Link AirPlusXtreme G 108Mbps Wireless Cardbus Ethernet Adapter	$59	
Network Interface Cards (PCI)	D-Link Airplus Xtreme G PCI Adapter	$115.98	Two used ($57.99 each)
Total		**$259.98**	



We'd like to believe it's possible to wirelessly send data at 108Mbps, but realistic throughput is much lower.



Once you access the D-Link router's Web-based configuration utility, click Run Wizard to configure its basic features.

We selected 128-bit encryption for better security, but be aware this will reduce your throughput.

http://192.168.0.1 into the Address box, and pressed ENTER. In the pop-up screen, we typed admin in the User Name field and left the Password field blank. This took us to the D-Link's home screen. From there, we clicked Run Wizard, clicked Next, and set up our new password. We chose our time zone from the drop-down menu and clicked Next, and the setup wizard automatically detected we were using a dynamic IP address. On the next screen we entered a new SSID (Service Set Identifier, our network's name) and clicked Next. We selected 128-bit encryption, the strongest encryption available on the D-Link, and clicked Next. We clicked Restart and Close and opened our Web browser to verify we had an active Internet connection.

We recommend checking your manufacturer's Web site for firmware updates as part of your router installation. In our example, we surfed over to D-Link's home page (www.dlink.com) and selected our router from the product menu. We clicked the Firmware link and clicked the picture that represented our model revision. When downloading firmware, exercise extra caution, as a bad firmware update can permanently ruin your router.

Install and configure the adapters. Installing and configuring our adapters wasn't too difficult or time-consuming. Starting with the PC Card adapter, we inserted the D-Link AirPlus Xtreme G DWL-G650 driver CD into our CD-ROM drive. We clicked Install drivers, Next on the following four screens, and Finish. We shut down our computer and inserted the adapter into an open cardbus slot. After we restarted our computer, we clicked Next to install the software automatically and clicked Next again. We clicked Finish, and the D-Link Configuration Utility automatically launched in our System Tray.

Before we configured the PC Card adapter, we installed PCI adapters on our two desktop PCs. We removed the side panels from our shut-down PCs and found an open PCI slot on each motherboard. D-Link had the foresight to include back mounting panels of two separate lengths, and we picked the one that matched our case. We lined up the adapters, gently pressed them into place, and attached the antennae. If you already have a jungle of cables behind your PC, you might want to consider a wireless USB adapter (see the "Bling Bling" sidebar).

When we configured the PCI adapters, we were pleased to find the process was almost a mirror image of configuring the PC Card adapter. We followed the same instructions, and the D-Link PCI adapter's quick install guide warned us of two potential nuances. Windows XP users may receive a dialog box indicating the PCI adapter has not passed Windows Logo testing after clicking Next on the Found New Hardware screen. Click Continue Anyway to proceed. Windows 2000 users may receive a Digital Signature Not Found dialog box after restarting. Click Yes to finish the installation.

Configuration utility. Once we installed the adapters, we used D-Link's Configuration Utility on both PCs to match their settings to our router. We right-clicked the XP Networking icon in the System Tray and clicked View Networked Connections. We clicked Advanced, unchecked Use Windows To Configure My Wireless Network Settings, and clicked OK. Next, we double-clicked the green utility icon in the System Tray. In the D-Link AirPlus Xtreme G Wireless Utility, we clicked Configuration, replaced the default SSID, and clicked Apply. We clicked Encryption, entered our WEP key, selected 128 bits from the drop-down menu, and clicked Apply.

Our network was nearly complete after we configured our devices to conform to each other. Using WinXP's Networking Wizard was our last big step before we would be zipping files over our network. On our desktop PC, which we used to configure the router, we clicked Start and My Network Places. We clicked Set Up A Home Or Small Office Network (located under Network Tasks) and Next twice. We clicked This Computer Connects To The Internet Through Another Computer On My Network Or Through A Residential Gateway and clicked Next again. We clicked Let Me Choose Connections To My Network and Next twice.

To keep things simple, we typed Workstation 1 in the Computer Description field and ONE in the Computer Name field. We clicked Next, entered Sandhills as our Workgroup Name, and clicked Next. We looked over our settings and clicked Next. Once the Wizard had configured our computer, it prompted us to create a disk with our network settings. You'll only need to do this if some of the PCs you're networking use Windows 95/98/Me/2000. Because our systems were running WinXP, we

clicked Just Finish The Wizard; I Don't Need To Run The Wizard On Other Computers, then Next, and Finish. We repeated the process for our other desktop PC (Workstation 2) and laptop (Wireless).

Confirmation. To confirm our PCs were connected to the network, we clicked Start, My Network Places, and View Workgroup Computers. Each PC's icon appeared in the window, so we knew we were in business.

WinXP has a folder for shared files coincidentally named Shared Documents, but you can share any folder or hard drive (or your entire hard drive, for that matter). We created a new folder on our Desktop, right-clicked it, and clicked Sharing And Security. We clicked the Share This Folder On The Network checkbox, Apply, and OK. An open-palmed hand cradling the folder replaced our original icon, indicating we were sharing the folder's contents on the network.

Testing

Once we were sharing files and an Internet connection on each of our PCs, we had the essential building blocks of our wireless network in place. While small files zipped through the air from system to system with ease, we wanted to see if the turbo technology lived up to its ultra-fast billing.

To test the D-Link router, we connected it to one of our lab PCs, which sports an Athlon 64 3000+ 2GHz CPU and 512MB RAM, to send a 100MB folder of assorted files to our laptop, which has a Pentium 4 2.2GHz processor and 256MB RAM.

Our results proved those snazzy advertisements of more than 100Mbps throughput aren't accurate. Without any encryption using Dynamic Turbo G Mode, we transferred the files 10 feet at 26.6Mbps, 150 feet at 14.1Mbps, and 250 feet at 9.75Mbps. Once we set up some obstructions to simulate network performance in a home or office, we transferred the files 150 feet at 8.6Mbps and 250 feet at 5.1Mbps. While these are still good results for a wireless router, real-world limitations, such as physical obstructions and network overhead, will limit your throughput.

To our surprise, our throughput was actually better in some instances when we used encryption. When we used 128-bit encryption, we achieved throughput of 22.4Mbps, 16Mbps, and 12.1Mbps at 10 feet, 150 feet, and 250 feet, respectively, with no obstructions. Our obstructed test returned throughput of 150 feet at 7.1Mbps and 250 feet at 3.7Mbps. We expected the encrypted signal to lower our throughput across the board, but a spokesperson for D-Link informed us encryption on new D-Link routers is hardware-based; there shouldn't be a difference in throughput.

Final Remarks

Buying all of our hardware from one manufacturer turned out to be helpful. If we had wanted to, we could have networked our computers immediately after we had installed our wireless NIC's drivers. Of course, this would have left our network exposed to anyone within range of our router's signal. Configuring the router can be a little tricky if this is your first networking project, but it's nothing you can't accomplish on a spare Saturday afternoon.

If you're a hardcore gamer who lives for LAN parties, a wireless network might be too slow in some instances. Otherwise, a wireless network will handle high-speed Internet and basic file sharing without all of the messy CAT 5 cable. RS

by Vince Cogley

The Great Wall Of Wi-Fi

The Great Wall of China. Fort Knox. Alcatraz. All of these imposing structures are renowned for keeping unwanted guests out (or in). While we find it highly unlikely a seething horde of Mongols will beat down your door and hack your wireless network, there are plenty of other invaders waiting to do some wireless looting and pillaging. Fortunately, an alphabet soup of security options is available to repel these digital barbarians.

Encrypting your signal is your first line of defense. The two most popular forms of encryption are WEP (Wired Equivalency Protection) and WPA (Wi-Fi Protected Access). WEP uses either a 64-bit or 128-bit key to encrypt data sent over a wireless network. A 64-bit key uses 10 hexadecimal digits (letters A-F and numbers 0-9) while a 128-bit key uses 26 hexadecimal digits. In theory, anyone who doesn't have your WEP key will be able to decrypt data sent over your network. As a result, WEP is usually strong enough to prevent casual users from accessing your network, but anyone who is persistent and has the right software can crack your key.

WEP's biggest weakness is that its key remains static, a flaw WPA remedies. According to the Wi-Fi Alliance, WPA requires a password and uses dynamic key sessions, automatically changing the encryption key every five minutes; by the time a cracker has cracked your key, your router is already using another key. WPA is your best bet for encrypting data.

Use MAC (Media Access Control) filtering to only allow devices with a specific MAC address to connect to your network. To determine each computer's MAC address in Windows XP, click Start and Run and type **cmd** to open a command prompt. Type **ipconfig /all** and look for the 12-digit number listed after Physical Address. This is the computer's MAC address. Consult your router's users manual and allow your router to accept connections only from your PC's MAC addresses.

In addition to these security measures, you can make your router more difficult to find. All routers have a default SSID (Service Set Identifier), and crackers who are aware of these defaults can use them to join your network. Thwart their efforts by changing your SSID to a unique name and disabling the broadcast option on your router. This decreases the likelihood a cracker will find your network and hack into it. ▲

Build A Combination Wired & Wireless Network

Ready, Set, Connect

Build #37 Skill Level: 1 2 3 4 5 *Apprentice*

Sure, one family computer is more than enough right now. After all, you use it only to surf the Web, check email, and occasionally chat with extended family via your trusty Web cam. But sooner or later, your spouse will catch a nasty case of the online auction fever and you'll find yourself looking longingly at the systems that line your local office store's shelves. Of course, that's when all four of your children will point out that they need to use the computer to finish their respective homework assignments. So now you have three or more computers (one of which is upstairs), and you need to extend the first computer's broadband Internet to the other computers. Welcome to the wonderful world of wired and wireless networking.

Goal

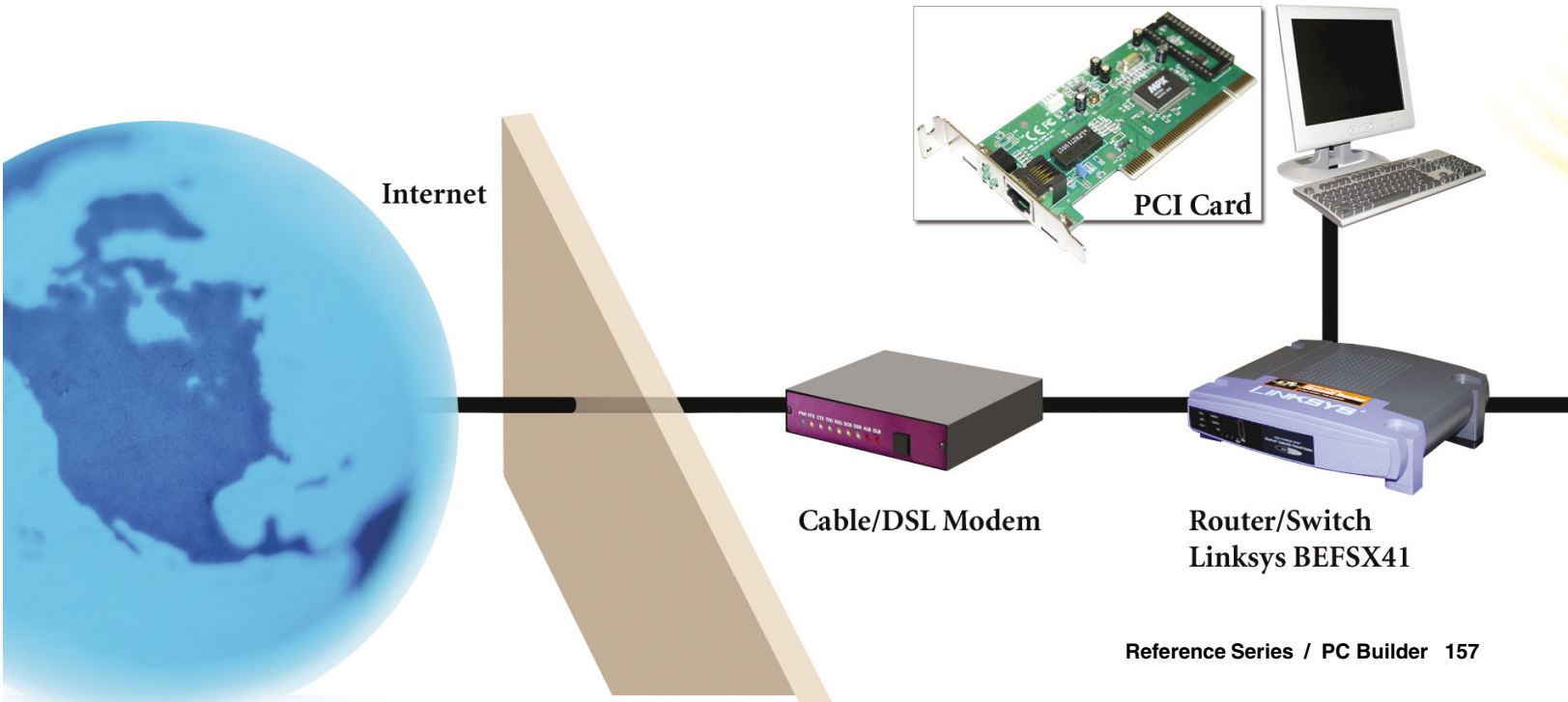
Slapping together a bunch of network devices is only half of the networking battle. Once you've connected every computer to the Internet, you'll need to hide your networked computers from the outside world and erect other digital defenses against attackers. You may also want to configure your PCs to share files. Configuring a secure, flexible network is a time-consuming task, but it's worth the effort. If you follow our footsteps, you can jump from networking newbie to the family or small-office/home-office network administrator in a day.

We built and configured a typical home- or small-office network consisting of several desktops and a notebook. One of the PCs is wired (it transfers data via a network cable), and the others use a popular wireless technology to fling information back and forth. Our wireless computers include three desktops and a notebook. All of our computers can access the Internet simultaneously, and all can share files over the network. We also enabled several security measures (including a firewall and encryption), which means we can leave the office without feeling as though we left the front door unlocked.

Background

Our planned network connects to the Internet via a cable or DSL connection, so we kicked off our shopping by picking out a router. We also put a switch, a wireless AP (access point), several wireless adapters, and a few Ethernet cables on our list.

Router and AP. The router stands between the outside world (the Internet) and your home network, which makes it one of the network's most important pieces. A router "routes" network traffic to your computers. In our case, the router directs traffic between individual PCs and also handles data flowing to and from the Internet. ISPs generally assign only one IP address to a home or office, which means that only one of your computers can connect to the Internet. The router assumes your main IP address and then generates extra IP addresses for your other computers. As a result, outside users can only see



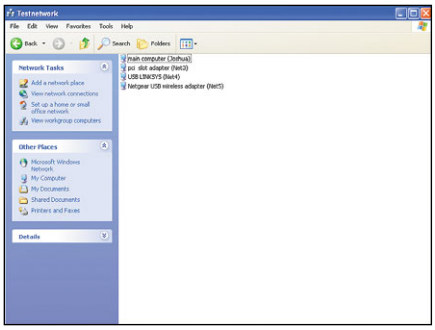
As long as you buy devices that support the same wireless standard, you can mix and match brands. That said, users who plan to stack devices on top of each other will probably want to stick to a single brand. Our Linksys router (bottom) and wireless access point (top) look like they're made for each other. In fact, they are.

the router's IP address, not the computers that make up your network. Most ISPs permit routers and even encourage users to use the devices, but you may want to ask your ISP before investing in the hardware.

Cable and DSL modems connect to PCs and routers via the same method: a network cable (also known as an Ethernet cable). That means that if we switch from one broadband service to another, we won't need to change our network's devices. Many routers offer extra features, including firewalls, switches, and wireless AP capabilities. If you already have a router, you can add wireless capability to your network by attaching a standalone AP. We selected a router and a separate AP to show you each device's setup and configuration needs.

Our Linksys BEFSX41 router includes a hardware firewall that monitors your Internet traffic and blocks suspicious data transfers and a four-port switch that supports up to four PCs via Ethernet cables. If you have more than four wired PCs, you'll need to buy another switch and then plug the extra switch into one of the router's switch ports (this configuration is known as a daisy-chain).

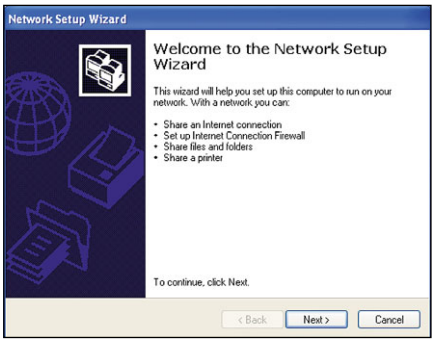
We chose the Linksys WAP54G AP because it boasts the IEEE 802.11g wireless network standard. The 802.11g standard is fast: It supports up to 54Mbps (but don't expect to see actual transfer speeds that



Once you run Windows XP's Network Setup Wizard, you can enter each computer's shared files via the network.

high) and it also supports 802.11b devices, which makes our network very flexible.

Adapters. Our router's switch supports network transfer speeds of 10Mbps and 100Mbps, so we yanked a generic 10/100 Mbps PCI Ethernet card (for our wired PC) from one of our test machines, but we spent more time choosing our wireless adapters. We picked the Linksys WMP-54G PCI adapter, which has a long, flexible antenna. We also chose the Netgear WG111 USB adapter, which is a pocket-


Network Setup Wizard
Welcome to the Network Setup Wizard
This wizard will help you set up this computer to run on your network. With a network you can:
• Share an Internet connection
• Set up Internet Connection Firewall
• Share files and folders
• Share a printer
To continue, click Next.
< Back
Next >
Cancel

You can use your router's configuration utility to distribute Internet access to your other computers, but you'll want to run WinXP's Network Setup Wizard if you plan to share files between networked computers.

knife-sized device that plugs directly into your PC's USB port. If you plan to tote the adapter from one computer to another, you'll love the tiny WG111. We also bought the U.S. Robotics USR5410 notebook PC adapter, which plugs into your notebook's PCMCIA slot. The card has a special Turbo feature that lets it transfer data at unusually high speeds, but it can only support Turbo mode when transferring data to another U.S. Robotics Turbo device. We didn't have any trouble connecting the device to our standard network.

We used several typical PCs to build our network, all of which had CD-ROM drives and USB ports. We used Windows XP's Network Setup Wizard to configure our PCs. Although all of our systems ran Windows XP Home or Pro, you can load the Network Setup Wizard onto a floppy and then run the wizard on older Windows-based machines, which means that you aren't restricted to WinXP machines when building a similar network. That said, you'll need at least one PC that has WinXP to run the new Network Setup Wizard.

Parts List

Component	Model	Price
Router	Linksys BEFSX41	$70
Access Point	Linksys WAP54G	$83
PCI Card	Linksys WMP54G	$59
USB Adapter	Linksys WUSB54G	$70
USB Key	Netgear WG111	$68
PCMCIA Card	U.S. Robotics USR5410	$60
Total		**$410**

NOTE: Tax and shipping costs are not included.

The Build

If you've built home networks before but haven't bought new devices in several years, you'll be pleased to know that most networking device manufacturers now toss decent instructions into product boxes. We easily followed each device's instructions, but we found that Linksys devices had the best installation guides and manuals. Even users who have never touched a networking device will understand the plain-English instructions and detailed troubleshooting information.

We don't have cable or DSL at our office (we're still trying to convince our editors that cable TV is a crucial part of every writer's equipment), which meant that we couldn't connect our router to a traditional cable or DSL modem. If you build this network yourself, you'll need to connect one end of a network cable to your modem's port and then connect the other end to the BEFSX41's WAN port. We used our office's ultra-high-speed Internet connection in lieu of a cable modem. We found that we couldn't distribute Internet access to our test network's PCs when we plugged the office connection's cable into the router's WAN port, so we plugged it into one of the router's switch ports.

Once we connected the PC to the router and the router to the Internet connection, we powered on the router and the PC. (You'll want to turn on your cable modem or DSL modem, power on your router, and then power on your main computer.) Don't power on any other computers, even if they are connected to the router via network cables. If you need to troubleshoot while configuring your router, you'll save time by dealing with a single PC.

As soon as the computer powered on, a small bubble appeared above the System Tray, indicating that Windows recognized the hardware. So far, so good. We double-clicked the Internet Explorer icon and immediately ran into trouble. We weren't surprised to see that the browser didn't display a Web site (after all, we hadn't configured the router yet), but we were surprised that Internet Explorer didn't open a standard browser window. Instead, it opened the Internet Connection Wizard, which informed us that the computer didn't have an Internet connection (No kidding, we said).

The wizard offered two options: View The ISP Offer Provided By My Computer Manufacturer and Run The New Connection Wizard So I Can Select Another Connection Method. We didn't expect to see any manufacturer ISP offers (after all, we built the system ourselves), so we chose the first option out of curiosity. Oddly enough, the wizard then displayed: Congratulations! You Are Ready To Go! When we clicked the Finish button, the standard Internet browser immediately appeared. We suspect that you won't encounter this situation unless you have just installed WinXP and are opening the Internet Explorer browser for the first time, as was the case with our machine.

Configuring the router. Unlike adapters and APs, which often require configuration software, the router stores its own utility. We accessed the utility by opening a browser window, entering the router's default IP address (192.168.1.1), and then pressing ENTER. The browser immediately displayed a Connect To 192.168.1.1 window that included User Name and Password fields. Linksys assigns a password to the router by default (admin), so we left the User Name field blank and then entered admin in the Password field. Once we entered the configuration utility, we noticed that Linksys breaks the router's option categories into several tabs, including Setup, Firewall, Password, and Status.

We started with the Setup tab, which has basic information, such as Time Zone, Host Name, and WAN Connection Type. In some cases, you may need to enter your ISP's Host Name and Domain Name. If your ISP requires you to enter this information, you can probably find it on the docu-

System Notes

Router	Four 10/100 switch ports, One 10/100 WAN port, DMZ, supports up to two IPSec VPNs, Stateful Packet Inspection, 60-day Symantec Norton Internet Security 2003 trial
Access Point	IEEE 802.11g, 256-bit WPA encryption, 64- and 128-bit WEP encryption

mentation your service provider left when it installed your cable or DSL modem. If you can't find it, call your ISP. Our ISP doesn't require host and domain names, so we simply selected our time zone and then selected Obtain An IP Automatically from the WAN Connection Type drop-down menu. The router automatically filled in our LAN IP Address info, so we clicked Apply and then clicked Continue when the Settings Are Successful window appeared.

Next, we clicked the Password tab and then replaced "admin" with a different password (no, we won't tell you what it is). Manufacturers assign default passwords to routers and access points. Be sure to change these passwords right away. If you don't, you're leaving the door open to malicious users. We clicked the Firewall tab and then clicked the Enable radio button in the Advanced Firewall Protection section. The Firewall page has several options, but we like the router's default firewall settings, which protect our PC from most attacks without limiting our Internet surfing.

Configuring the AP. The Linksys WAP54G closely resembles our router. In fact, its legs and rubber feet match the four depressions on the top of the router, which means you can stand the AP on top of the router. That said, many users find that the AP broadcasts farther if it is attached to a tall object, such as a wall. To that end, the WAP54G includes a detachable wall-mount bracket that lets users securely attach it to a high location. But before you place your AP at the top of the tallest wall in your house, make sure you have an Ethernet cable that can span the distance between your AP and the router; although the AP frees your PCs from cables, it can't cut its own leash.

If you plan to network PCs that are in separate rooms, place your AP so that only a minimum number of walls stand between the AP and the PC's adapter. Walls and other obstructions can greatly reduce your AP's signal strength. All of our network's PCs were in the same room, so we simply stacked the AP on top of the router, which we placed on top of our main computer. The top of the router has vents that allow heat to escape, but the AP doesn't block the vents, thanks to its long legs.

We plugged a network cable into the AP's lone LAN port and then plugged the other end into one of our router's switch ports. Unlike the router, the WAP54G doesn't store its own configuration utility. Instead, you'll need to run the utility from the included CD. The setup wizard displayed several important settings, including the channel. By default, the AP uses channel six. If other users have networks nearby and you have trouble reaching your own devices, you can switch to a different channel, which may reduce interference.

Thanks to the main page, we noticed right away that the AP's security features were disabled. If your wireless devices don't encrypt data before tossing it through the air, nearby malicious users can use their own wireless devices to intercept and view your files. Our AP supports WPA (Wi-Fi Protected Access) and 64- and 128-bit WEP (Wired Equivalent Privacy) encryption. We chose 128-bit WEP encryption and then entered a Passphrase. The utility automatically generated a WEP key that consisted of characters and numerals. We wrote down the key so we could use it to authenticate our wireless adapters later and then exited the utility.

Look for routers that have extra features, such as hardware firewalls and built-in switches. If you're building a wired and wireless network from scratch, you may want to pick up a router that has an integrated wireless access point.

Connect your cable or DSL modem's cable to the router's WAN port. Some routers, such as this Linksys BEFSX41, include switch ports that let you connect PCs via network cables.

Configuring the wireless adapters. We installed and configured the Linksys WMP54G PCI card in less than five minutes. We opened one of our computers, popped the card into an empty PCI slot, and screwed the adjustable antenna into place. When we powered on our computer, the Windows Hardware wizard asked for the adapter's CD. The wizard protested because the CD's drivers weren't Windows-certified, but it installed them when we clicked Continue Anyway. We clicked our System Tray's Linksys icon to open the Wireless Network Connection window, selected our network, and entered the AP's WEP key. The Wireless Network Connection window indicated our adapter had a strong network signal, so we closed the window and moved to the next computer.

Next, we installed the Linksys WUSB-54G USB adapter. Although we didn't need to open the computer's case to install the adapter (we simply plugged it into a USB port), we followed the same steps as we did with the WMP54G to configure the adapter. The WUSB54G has a long cable, so we placed the adapter on top of our computer, which meant that the adapter could easily see the AP.

We installed Netgear's WG111USB adapter without a hitch. At about $68, it is one of the most expensive adapters in our network, but it's also the smallest. The device plugs into your computer's USB port, which means that your AP won't be able to see the adapter unless your PC has front USB ports. Line-of-sight setups generally offer the strongest wireless signals, but if there aren't any major obstructions between your computer and the AP, your adapter will probably pick up the signal. If you have trouble finding a decent signal, you can attach the included 5-foot USB cable and place the ultra-portable adapter in a better location. Unlike the Linksys devices, the WG111's instructions asked us to install the adapter's drivers before we plugged the device into the computer.

We slipped the last wireless adapter, the U.S. Robotics USR5410 card, into our notebook's PCMCIA slot after we installed the software. We were glad to see the card's package includes a 30-day trial of Symantec Norton Personal Firewall 2003.

File sharing. Once we set up each computer's wireless adapter and connected all of the PCs to the Internet, we started our last task: configuring the PCs to share files over our small network. If you never share files

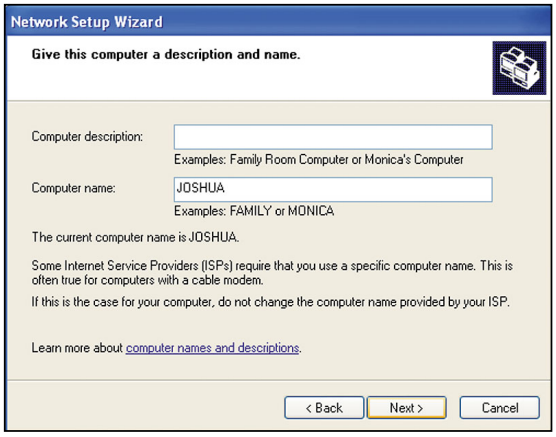
between computers, or if you're content to lug a floppy disk or CD to and fro, you won't need to complete this step. But if you want to put your digital music collection (which you built by ripping your own CDs) onto every computer without leaving your chair, you'll need a network that supports file sharing. We used WinXP's Network Setup Wizard, which gathered information about our network and then automatically configured our computers.

We returned to our main computer and then started the wizard by clicking Start, My Computer, and My Network Places (you'll see My Network Places on the left side of the My Computer window). We clicked Set Up A Home Or Small Office Network under Network Tasks. We clicked Next at the Welcome page and then clicked Next at the Before You Continue page, which asked us to double-check our devices to make sure they were properly set up.

Next, we chose our network from the Select A Connection Method page. The wizard configures both Internet access and file sharing, so we weren't surprised to see that the wizard asked us how our computers connect to the Internet. Each network title includes a brief description and a View An Example link. If you have trouble matching your network to the descriptions, click View An Example under any network title. The link opens a new window that displays a diagram of the network. We saw our network right away: This Computer Connects To The Internet Through Another Computer On My Network Or Through A Residential Gateway (in our case, the gateway is the router). We were surprised to see that the network diagram showed only one of the two networks that the description mentioned (it depicted a computer accessing the Internet through another computer). We clicked the network's radio button and then clicked next.

The next page told us our computer had more than one network connection. We clicked the Let Me Choose The Connection To My Network button and then clicked Next. The next page listed several connections, including our computer's FireWire ports and the Realtek RTL8169/8110 Family Gigabit Ethernet NIC (our computer's built-in Ethernet connection). If you're not sure which port description matches your Ethernet port, click Learn More About How To Determine Your Internet Connection. We selected our Ethernet port and clicked Next. The wizard recommended we select a different network because it believed that all of our computers connected directly to the Internet, making them all vulnerable to attack. However, our router's firewall protects all of our computers, including our wireless PCs (after all, they connect to the AP, which in turn connects to the router), so we continued.

Next, we entered a name and a description for our computer. Choose your names and descriptions wisely; other network users will see this information when your computer is connected to the network. Once we described our computer, we named our workgroup. By default, the wizard enters MSHOME in the Workgroup field. You can change your workgroup's name, but be sure to write the name down, as you'll need to enter this same name when you configure the other computers. If a computer has a different workgroup name than its siblings, the other computers won't be able to see it on the network.


Network Setup Wizard
Give this computer a description and name.
Computer description:
Examples: Family Room Computer or Monica's Computer
Computer name:
JOSHUA
Examples: FAMILY or MONICA
The current computer name is JOSHUA.
Some Internet Service Providers (ISPs) require that you use a specific computer name. This is often true for computers with a cable modem.
If this is the case for your computer, do not change the computer name provided by your ISP.
Learn more about computer names and descriptions.
< Back
Next >
Cancel

Don't forget to name each computer. You can also enter a second label, such as the PC's location.

The final page, You're Almost Done, asked us if we wanted to create a Network Setup Disk. If you choose this option, the wizard will download itself to a floppy. You can use the disk to run the wizard on non-WinXP machines (as long as they run Windows). We finished the wizard, shared a file on the network (we right-clicked My Pictures, clicked Sharing And Security and then clicked Share This Folder), rebooted our computer, and then powered on our next PC. We ran the wizard, returned to My Network Places, and then clicked View Workgroups, which displayed both computers. Next, we ran the wizard on our remaining PCs and then checked to make sure that we could see all of the computers: They were visible. Mission accomplished.

Testing

Because we built a network instead of individual computers, we couldn't run the benchmarks we used to test other systems. Instead, we tested our network by connecting each PC to the Internet (we opened Internet browsers to make sure we could surf the Web). We also transferred files between computers to determine whether our PCs had successfully logged into our workgroup.

Final Remarks

Despite the setup wizards and network configuration wizards, we often run into headache-inducing problems when building networks. Whether you are changing settings manually or running wizards, we suggest troubleshooting problems by changing one setting (or choice within the wizard) at a time. In our case, we chose the wrong network while running the Network Setup Wizard because we based our choice on an inappropriate diagram. Although the diagram showed a similar network, the network description mentioned only a hub (which is similar to a switch). It didn't mention the router, which our network has. We found the correct network configuration through trial and error.

We forgot all about our headaches when we saw our computer's folders pop up in the Workgroups folder. If you find yourself stumped, take a breather and approach the problem from a different angle. And keep in mind that when all is said and done, the working network is worth the trouble. RS

by Joshua Gulick

Build Your Own Home Security Network

An All-Seeing PC Worthy Of James Bond

Build #38 Skill Level: 1 2 3 4 5 *Journeyman*

By now, you're worldly enough to know that everyone is out to get you. Fearsome intruders prowl your home's perimeter on dark nights. Thieves and thugs bide their time on the sidewalks outside your office, waiting for just the right time to strike. And, perhaps worst of all, your adolescent children insist on making trouble by sneaking out for wild parties.

Modern security and PC technology can put at least a few of your fears to rest. You don't have to invest thousands in a professionally installed security system to keep tabs on your assets and your family, and you don't have to be a technological whiz to set up a system yourself.

Goal

With a little patience, some trial-and-error persistence, and a modest technology budget, you can create and customize a PC-based networked security system that will give you peace of mind that only a party-crazed teen can destroy. Follow along and we'll show you how we set up just such a system.

Background

When it came time to select the parts for our security system, we knew peripherals would consume a huge chunk of our technology budget. So we spent sensibly to build our system's centerpiece. We bought a SOYO motherboard that came with a Pentium 4 2.8GHz CPU. This was by no means the fastest processor we could find, but the 2.8GHz version had plenty of speed, and better yet, a very reasonable price tag.

Memory-wise, we took a bit of a risk by going with 512MB of RAM instead of 1GB, hoping that this relatively modest amount would keep our system running without glitches. We bought budget-priced RAM, too, and spent only $65 for a single Ultra PC2700 DDR RAM stick.

Though we knew our computer would need to handle the demands of a lot of data-heavy graphics applications, we didn't want to drop a load of cash on a video card specifically designed for gaming. We went with ATI's All-In-Wonder 9600 XT card that's equipped with 128MB of memory. This card has the muscle to handle the complexities of 3D gaming and some nice extras, including S-Video and Composite video input and output as well as TV antenna input, all of which might come in handy for future security projects.

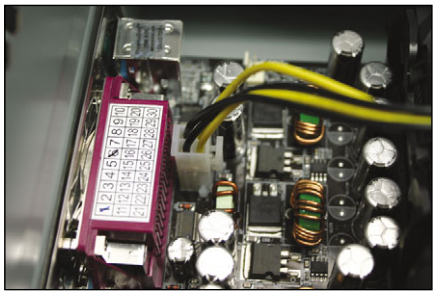
To house our system we selected an Antec midtower case with a 300-watt power supply. Although 300 watts is the bare minimum for most new computers, we weren't worried about power in this particular system, primarily because so many of our components have their own power adapters.

We decided early on not to skimp when it came to security cameras. Many companies manufacture these devices, but as with so many computer parts, you get what you pay for. And many cameras create grainy images even in full daylight. We wanted cameras that would provide accurate visual information and offer enough flexibility to adapt to unforeseeable security challenges.

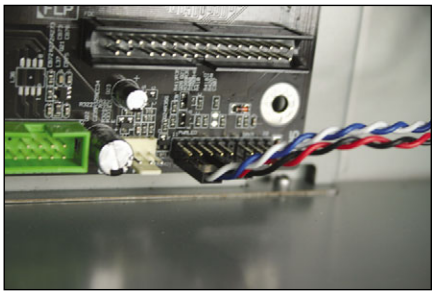
We bought two D-Link DCS-5300W cameras. These beauties are loaded to their lenses with high-tech capabilities that make them perfect for varied settings. They include a CCD (charge-coupled device) sensor instead of cheaper CMOS sensors, which typically have less impressive resolution ratings and lower overall image quality.

One of the biggest benefits of these expensive cameras is that they work within the confines of an 802.11b wireless network, meaning you don't have to struggle with hundreds of feet of Ethernet cable. Through the network, or anywhere in the world (using the right IP address and a high-speed Internet connection), you can control pan, tilt, and digital zoom features on each camera, and this model also comes complete with a microphone to record sound, as well as built-in motion detection that will send email alerts to an account and notify you of suspicious activity.

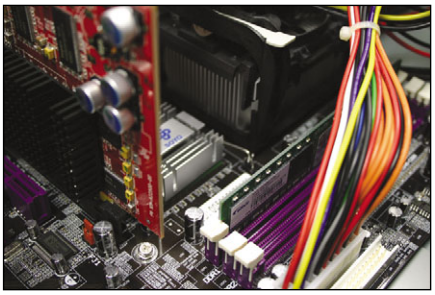
To round out our system with a third camera, we figured that for easy interoperability it would be best to stick with a D-Link model. We purchased a D-Link



Our Pentium 4-compatible motherboard needed two power inputs, including this second, smaller connector.



The power and reset button wires are easy to connect, thanks to the clearly marked headers on the motherboard. SOYO's manual indicates where the connectors for LEDs should go.



We inserted our single RAM module into the slot closest to the CPU socket.

DCS-900W. This model doesn't have nearly as many features as the DCS-5300W, but its redeeming trait is that it can connect to the same 802.11b network we planned to set up for our other cameras.

We used a previously purchased monitor to keep an eye on output from our three cameras. However, we wanted to make sure the budget for this system included a monitor worthy of a true security setup. To that end, we found a massive 21-inch Philips CRT model for about $350. A screen this big should provide plenty of on-screen real estate for multiple security- and network-related tasks running simultaneously.

The PC Build

We opened our case and lowered our motherboard into the case to confirm that the Antec port plate wasn't going to work for our purposes. We snagged the plate from our SOYO box, tapped the case's plate out with a screwdriver, and snapped the new plate into place. The case appeared to lack the correct number of standoffs and screws, but after a little searching we found a bag of extra screws and standoffs in a compartment on the back side of the case. We inserted the standoffs for our SOYO motherboard and made sure that there were no standoffs in spots where there were no holes in the board, all the better to avoid a catastrophic shorted circuit. We used the screws from Antec to make sure our board didn't slide around on top of the standoffs.

CPU. We pulled the lever on the side of the CPU socket out slightly and then straight up to open the socket for processor insertion. We aligned the processor so that the golden arrow on its corner pointed toward the hinge of the CPU socket lever.

Parts List

Component	Model	Price
Case	Antec Solution Series Mid-Tower Case With 300W PSU	$49
Motherboard/Processor	SOYO P4I 845PEV 1.0 Socket 478 Motherboard/Intel P4 2.8GHz Processor Bundle	$190
Memory	Ultra 512MB PC2700 DDR 333MHz Memory	$65
Hard Drives	Maxtor 160GB 8MB Cache	$104
Video Card	ATI RADEON All-In-Wonder 9600 XT 128MB	$279
Optical Drive	Samsung 52X/32X/52X/16X Combo CD-RW/DVD	$78
Monitor	Philips 21-inch CRT Monitor (201B4074)	$349
Router	D-Link AirPlus 2.4GHz Wireless Router (DI-624+)	$79
Cameras 1 & 2	D-Link DCS-5300W Wireless Cameras (x2) *	$800
Camera 3	D-Link DCS-900W Camera *	$144
Mouse & Keyboard	Logitech Black Optical Mouse and PS/2 Keyboard with 104 keys	$20
Operating System	Windows XP Home Edition	$90
Miscellaneous	N/A	$0
Total		**$2,247**

* Cameras purchased on sale

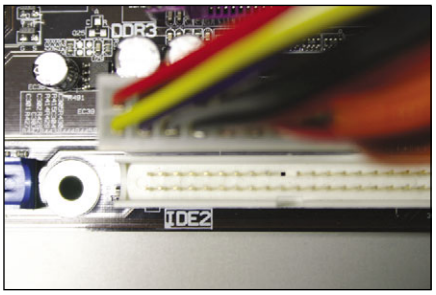
Drives. This Antec case has screwless drive rails to help install optical drives painlessly, but unfortunately, there were no instructions. To complete the installation, we first removed the plate covering a 5.25-inch drive bay, taking extra care to avoid slashing our fingers on the sharp edges. The metal plate came with a purple drive rail that we removed by lifting the release tab and then sliding the rail until it came loose.

With our optical drive on its left side, we attached the drive rail to the right side of the drive. To do this, we made sure the front of the drive rail (with the release tab) was at the front of the drive, inserted the back of the rail into a hole on the back of the drive, and then used our fingers to work our way up to the front of the rail, which we clicked into place in a screw hole at the front of the drive.

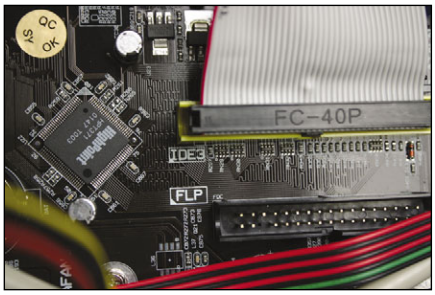
Then we found the locking sliders on the side of the drive cage. On the drive bay where we removed the metal plate, we slid the lock forward, pushed our optical drive until we heard a click, and then pushed the locking slider back toward the rear of the case to completely secure the drive.

Installing the hard drive didn't take nearly as much work. We pulled the lever on the smaller drive cage to

The CPU fan connects to this header, which is near the CPU socket.



We connected our optical drive to the IDE 2 slot on the edge of the motherboard.



We plugged our hard drive data cable into the motherboard's IDE 1 connector.

remove it from the case, used a couple of screws to secure the hard drive, and then we pressed the cage back into its original position in the case.

Wiring. Some motherboard models make it hard to connect wiring for case power and reset switches, but the SOYO made this process simple, with both headers clearly marked with labels on the surface of the circuit board. The manual came in handy for connecting other wires, such as the ones for case and drive LEDs.

The Pentium 4 2.8GHz CPU and motherboard required plenty of juice, provided by two cables from the power supply. These cables used 4- and 20-pin connectors that matched up to their obvious counterparts on the motherboard. While we were at it, we took white, 4-pin connectors from the power supply and connected them to the back of our hard and optical drives.

Then we pulled the 40-pin IDE cables from our motherboard box. We connected one end of one cable to the back of our hard drive and the other end of the cable to the IDE 1 connector on the motherboard. We repeated this step for our optical drive but instead connected it to the IDE 2 motherboard connector.

Movable Feast

Two camera capabilities—motorized heads and wireless connectivity—make certain models much more expensive than others. While movable cameras are nice, we think it's more important to have wireless features that negate the need for long (and expensive) Ethernet cable. ▲

Power. After double-checking our data and power connectors, making sure our drives were secure, and confirming that our power supply switch was in the On position, we pressed the power button. The computer came to life and loaded the motherboard's basic information screen. We pressed the DELETE key to access the BIOS menu. Here, we entered the SOYO Combo Feature menu, used the arrow keys to move to the second page of options, and changed the boot order so that the CD-ROM would boot first and the hard drive would boot second.

Software. As the computer restarted, we inserted our Windows XP CD into the optical drive, and the computer displayed a blue setup screen. We followed the basic prompts and chose to install a copy of WinXP on the C: drive. We opted not to create any partitions, and we selected the NTFS Quick option so that WinXP would format the hard drive in seconds instead of minutes.

The computer restarted itself and continued copying Windows files to the hard drive. After about 20 minutes, our copy of WinXP was ready to go. We opened the Control Panel and then the Device Manager to check on the status of our system's drivers. As expected, we found several yellow exclamation points that indicated driver issues.

We inserted our motherboard's driver CD and closed the window that automatically appeared. We right-clicked the first device with an exclamation point, clicked Properties, and clicked Update Driver. We let WinXP automatically locate the necessary driver on the CD. For each device, we repeated this process, and when Windows located more than one available driver, we selected the one that referred to WinXP in its path name. It bears noting that we skipped this process for the video card; for this device, we used the same process but substituted ATI's driver CD to make sure we installed the most appropriate software.

The Network Build

Building our system and installing appropriate drivers was easy. Making our security cameras cooperate with a router, however, was borderline exasperating. We encountered numerous problems during the setup procedure, but we did successfully complete the system.

We started by unpacking our D-Link DI-624 wireless router. We connected an Ethernet cable to LAN port 1 on the back of the router and connected the other end of the cable to our motherboard's Ethernet port. Then came the AC adapter, which we plugged into a power strip. After restarting the PC, the router seemed to be working correctly, and when we typed its IP address into a browser, the configuration menu appeared. We clicked Wizard and entered basic setup information, but we skipped

Timesaver

If you want to mix and match camera models on your network, try to confirm that each camera will work with the same surveillance software. You can run more than one surveillance application if you need to, but doing so makes it more difficult to monitor camera output. ▲

These sliding locks for the drive bays are confusing at first, especially because there were no instructions included with the case.

We initially plugged our cameras into the LAN connectors on the back of the router to establish a connection. To make the cameras work wirelessly, we simply disconnected them from the router.

Keep an eye on the LEDs that grace the front of your router. These lights indicate whether the router is establishing active connections with your wireless cameras.

over the encryption configuration for the time being.

The setup procedure for our first DCS-5300W camera was similar. We plugged an Ethernet cable into the camera, and the other end of the cable went to a LAN port on the router. The AC adapter plugged into the camera and power illuminated the camera's two front-mounted LEDs. We inserted the camera's software CD, clicked IP Installer, and the program listed a MAC address and IP address for the camera. We clicked the MAC address and then the Link button on the left side of the screen.

We typed the IP address of the router listed in the quick start manual to load the device's configuration page. Then we ran the setup wizard to configure a few basic settings; the only real change we made here was to rename the SSID from Default to the same SSID used in our router, but users who want to use encryption can engage this option here so that the camera will work correctly with the router. We also picked an easy-to-remember password for our administrator login.

Once we completed the wizard, on the Home tab we clicked Wireless, and from the Channel drop-down menu, we tried to select channel 9. Not all users will need to select a different channel, but we had to choose a new frequency to prevent interference from our in-office wireless LAN. Unfortunately, the configuration menu wouldn't let us pick a new channel. After digging through dozens of options and resetting the router numerous times, we stumbled upon a solution posted to D-Link's tech support site. We clicked the Advanced Tab and on the left side of the screen Performance. From the Super G Mode drop-down menu, we selected Super G Without Turbo, and then we clicked Apply. We returned to the Channel option, and this time we were able to change the channel to 9. We clicked Apply to save our settings.

Testing

To see if we could make the camera work wirelessly, we closed our programs, disconnected the Ethernet cable from a camera, and unplugged the AC adapter to reboot the camera. We started Internet Explorer and typed **http://*X***, where *X* was the camera's IP address. The camera's built-in software loaded and we surveyed our surroundings with the pan and tilt functions.

After confirming that the camera worked wirelessly, we returned to the configuration menus for both the router and the camera so that we could enable WEP encryption. We opted for 128-bit shared-key encryption. We typed in a new key and made sure that this key number was the same for both devices. After configuring the camera, we clicked Apply to save our changes, and then in the router's menu, we clicked Apply, too.

We then unpacked our second DCS-5300W and followed the same setup steps. We ran the IP Installer software, but there was still only one IP address listed, and this one address was for the first camera. This meant that our router wouldn't recognize the second camera. To resolve this, we left the second camera connected while rebooting the router. To do this, we typed the router's IP address in Internet Explorer to access its configuration menu. On the Tools tab, we clicked Misc. and Reboot.

About 15 seconds after rebooting the router, it recognized the second camera and assigned it an IP address, which we found using the IP Installer software. We selected the second MAC address, clicked Link, and the program displayed output from our second camera. We changed the settings for this camera to make the SSID and channel match our other devices and clicked Apply to save our settings.

We next had to make the cameras work with D-Link's IP Surveillance software. We didn't find this software to be very user-friendly, so we've included many of the steps needed to force the cameras into action. Launching IP Surveillance automatically lets the software recognize the cameras, but the screen is initially blank. To make the camera output show up on a monitor, the software needs more information.

We clicked Function Menu to access the configuration menu. At the top left,

Watch Out

Some wireless cameras are difficult to set up with certain routers. Sticking with the same brand for both products might help, but it doesn't guarantee an easy setup. ▲

we typed the IP address for our first camera and then clicked Insert. Doing this let us see the camera's output and then tweak settings for motion detection, alerts, and more. After we clicked Save, however, the main surveillance screen was still blank. To see camera output, we had to click and drag the first camera's icon from the top left to the middle of the screen.

We repeated these steps to access the second camera. To make the program display output from both cameras simultaneously, we clicked one of the multi-output icons on the left side of the screen. From there, we could configure the recording and alert options and pan and tilt the cameras at will with either the software or the remote controls.

Camera number three. We installed our DCS-900W much as we did the DCS-5300W cameras. After we connected the DCS-900W to our router, we ran the setup software, restarted our entire setup, and used the router's configuration software to make sure the camera's IP address was displayed correctly. Using IE and the camera's included software, we were able to view scenes through the camera with no problems. We disconnected the Ethernet cable and disconnected and then reconnected the camera's power cable; the camera's wireless connection worked fine after we clicked either the ActiveX or Java buttons in the browser.

We loaded the IP Surveillance software that came with the DCS-5300W. This program showed the output from our DCS-5300W cameras with no problem, and we used the configuration page to see the output from the DCS-900W. But when we returned to the main surveillance screen, the DCS-900W output went blank. D-Link tech support gave us a quick reason: The IP Surveillance software was not compatible with our camera model. As a workaround, we ran the two DCS-5300W cameras on the IP Surveillance software, the DCS-900W with its IPView Lite, and then switched between the programs.

System Notes

512MB DDR333 RAM (supports DDR333 and DDR266 up to 2GB)
Onboard 4-channel AC97 codec audio
Support SATA hard drives
Two rear-mounted USB 2.0 ports
Two pan-and-tilt, wireless security cameras with audio and motion detection capabilities
One wireless camera with motion detection, scheduled, and manual recording
Video card with Composite, S-Video, and TV tuner capabilities
10/100 Ethernet built-in

The back side of each DCS-5300W camera has an Ethernet port, a power port, and connectors for two antennas.

View from afar. Our three cameras worked great for keeping tabs on things while we were near our computer, but we also wanted to be able to watch output when we were miles away on another PC. Setting up this capability took hours of work and required a lot of help from the camera and router manuals. Because of the complexity and variation inherent in setting up cameras for remote viewing, we'll offer only the basic steps needed to make this feature work.

Because our cameras were connected to a router, we had to forward router ports for the cameras' video and audio. We did this by entering the IP address of each camera and by using unique HTTP and streaming ports for each camera. After we opened the router's ports, we had to forward the necessary ports used by our D-Link cameras. We did this using the Firewall options on the camera's configuration page.

It would've been easy to access the camera if we'd used a static IP address from our ISP. Unfortunately, our ISP (like most others) assigned dynamic IP addresses instead, meaning our home PC's IP address was likely to change every time we tried to view it from another PC. We had two options for making a remote connection: Try to get a static IP address from our ISP (most ISPs charge more for this option), or use a free service to obtain a pseudo-static IP address for easy access to our cameras. We found several sites that offered this service, including Dyndns.org (www.dyndns.org), TZO (www.tzo.com), and DHS International (www.dhs.org). We set up an account with Dyndns.org in only minutes.

Using this service, we added a redirect to create a static URL to connect to the dynamic IP address of our cameras from any browser. To make the redirect work, we had to add ":80" (for the open port on the camera) to the end of the redirect; otherwise, our URL wouldn't access the correct port and receive camera information.

This was one of the most involved processes in setting up our camera network, and it took a lot of tweaking to make it work correctly. For detailed steps on setting up remote viewing for an Internet-connected camera, see our online sidebar at www.smartcomputing.com/remoteaccess.

Final Remarks

Building our speedy PC was easy compared to making our cameras work properly; setting up the optics part of our network was frustrating and required far more trial and error efforts than we expected. But in the end, our network did the job we wanted it to, letting us monitor and record specific environments without significant slowdowns.

We should note that you don't have to spend nearly $2,500 to create your own home security network. By selecting cameras without pan-and-tilt capabilities, or simply by buying one or two cameras instead of three, you can drop equipment costs dramatically. With careful product selection and some persistence, you can put together a PC with enough processing power and surveillance features for most home and small office needs. RS

by Nathan Chandler

The Award-Winning MSI K8N Neo Platinum Motherboard is

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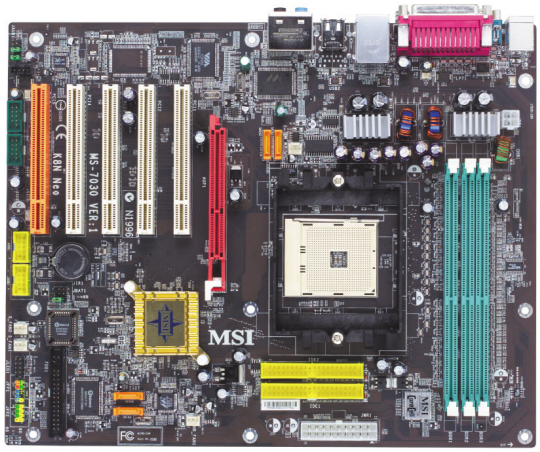

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Make A Monster PC Out Of Five Old Systems

We Hit The Auction & Garage Sale Circuit

Build #39 Skill Level: 1 2 3 4 5 ***Master***

We decided to leave some of the auction masking tape on Frank for extra flair.

If there was one thing Dr. Frankenstein wasn't short on, it was ingenuity. Although his moonlit adventures of searching for "aftermarket parts" for his infamous monster were questionable, at least he was resourceful.

With "It's Alive! Alive!" as our driving maxim, we struck out to build our own monster, sans grave robbing. We may have avoided the local cemetery, but our quest took us to some final resting places for PCs that avid PC builders usually avoid.

Goal

While we had $500 to spend, we knew resourcefulness and creativity would be far more important for this task than any amount of cash. Using only garage sales, classified ads, and other resellers of used computers, we had to piece together a Frankenputer out of parts from five used systems. We couldn't purchase any new components from local retailers, but haggling over the price on these systems was acceptable. With any luck, our PC (affectionately dubbed "Frank") would be better than any one of the original computers we purchased. As an additional goal, we would try to install Windows XP to give Frank at least some semblance of being a newer PC.

Background

We shed a little tear knowing we had to purchase the pieces to our monster PC from garage sales, though the potential to enjoy homemade lemonade was alluring. We figured hardware compatibility would be our most formidable obstacle, but missing or obsolete drivers, damaged hardware, and plain old wear and tear were also issues we expected to face. But because we were buying five computers, we guessed we could still find everything we needed.

During the planning stages, we established certain strategies we thought would optimize our Frank. We wanted to find one system with a case that would support multiple hard drives to maximize Frank's storage capacity. Our motherboard needed to have as many DIMM slots as possible, and we hoped we could locate a few 256MB memory modules; if Frank could roll off the production line with 512MB of memory, we'd be happy. The best CPU would probably stay nestled in its original motherboard, but swapping it out to a better mobo was still a remote possibility. At last, we grabbed our cash, classified ads, and sunscreen and struck out for the seldom explored territory populated with minivans and soccer moms.

After our tours of duty that included a used computer retailer, a state property auction, and more garage sales than we could remember, we considered ourselves seasoned used computer shoppers. Our ragtag band of PCs cost less than $500, but could we combine their components in a way that would make Frank more PC and less fire hazard?

The unusual suspects. We had assembled a true motley crew of PCs. The Gateway E-5200's Pentium III 550MHz processor was the fastest of the bunch, so the E-5200's CPU, mobo, and case would serve as Frank's body and brains. We also used the monitor, memory module, and hard drive. The CPU was an old, slot-style processor, which gave us a few disadvantages. It quickly squashed our fantasy of watercooling the CPU and

overclocking it to unheard-of clock speeds. If we had extra time, we may have been able to custom build our own water block; Frank may get his own watercooling apparatus someday.

The CPU's enormous heatsink-and-fan combo also caused problems. We had forgotten how small cooling apparatuses had become until we cracked open the E-5200's case. The E-5200's heatsink-and-fan combo literally consumed at least a third of the mobo's surface area and looked like it could act as a propeller for a small engine airplane. While the E-5200 came with an old internal SCSI tape drive, a CD-ROM drive (SCSI too!), and two 3.5-inch floppy drives, we only kept one floppy drive.

We were tempted to use the Optiplex GX1 as our main computer, but we only salvaged its memory module, hard drive, monitor, and "Property Of State Of Nebraska" sticker. The audio and video inputs were integrated into the motherboard, the optical drive was only a CD-ROM drive, and the mobo only had three DIMM slots. It also didn't look like we could have fit more than two hard drives in the case.

Much to our surprise, the EMonster 500 had a few useful parts the Dell and Gateway systems lacked. It was the only system that sported a DVD-ROM drive, and it had the largest hard drive among all of our computers. Throw in a snazzy custom eMachines keyboard, and we were glad we bought the EMonster 500.

Parts List

Price	Notes	
Case, PSU, CPU, Motherboard, RAM, Hard Drive, AGP Graphics Card, Floppy Drive, Monitor	$105	
RAM, Hard Drive, Monitor, Case Screws	$105	
RAM, Hard Drive, DVD-ROM Drive, Keyboard	$125	
Monitor, Speakers	$20	
PCI Graphics Card	$100	
PCI Graphics Card, PCI Sound Card, NIC	N/A	
Windows XP Home Edition SP1	N/A	Cost not included in total price.
Total	**$455**	

Our fourth and fifth PCs would provide us with peripherals that would make Frank extra cool. Our fourth PC yielded us our third monitor and a nifty pair of speakers; the fifth PC provided a Jaton PCI graphics card that would help us eventually build a triple-monitor system and an old Crystal ISA sound card we hoped would be our sound card.

The Build

While we used the Jaton graphics card from our fifth PC, we developed a case of itchy trigger finger and started building Frank with the first four computers we bought. We opened the Gateway E-5200's case and started tearing out drives. We removed the SCSI CD-ROM drive to make room for our DVD-ROM drive and also removed both 3.5-inch floppy drives because we thought we could use the extra space for a hard drive. We left the SCSI tape drive alone, but we would eventually send it on its way, too.

After wrestling with the Dell Optiplex GX1 for a few minutes, we finally opened its case. We pressed a small button in the bottom-left corner of the case's front and moved the rear case lock mechanism to the open position (see photo). The side panel swung open and reminded us of the DeLorean's gull-wing doors from "Back to the Future." Once inside, we grabbed the memory module and removed the hard drive from the hard drive cage, stopping only to admire the Optiplex's vintage heatsink venting.

We had a much easier time opening up the EMonster 500. The EMonster 500's hard drive mount was vertically mounted to the front of the chassis, so we kept the hard drive mount with a small hope we could find a way to mount it in the Gateway E-5200 to reduce the interior clutter. We later found out this was a futile attempt. Once we removed the DVD-ROM drive and memory module, we began putting Frank together.

Cable cleanup. We removed the Gateway E-5200's CPU fan (see "Super Size Me!" sidebar), IDE, SCSI, and floppy cables to examine the layout of the drive cages and the mobo. After we installed our memory modules from the other PCs, a quick glance revealed that Gateway either did not intend three separate hard drives to fit in the case, or they didn't anticipate someone would be crazy enough to try. Either way, this case was no place for claustrophobic components: The mobo's four DIMM slots were oriented so that it would be difficult to mount three hard drives in the hard drive cage without being dangerously close to the memory modules. When we tried to put three hard drives in the same cage, we couldn't run IDE ribbon cable from the drives to the mobo's IDE controllers. One of our hard drives needed to migrate to another location. Because a maximum of two devices can share an IDE controller, only three of our four available hard drives would actually be used.

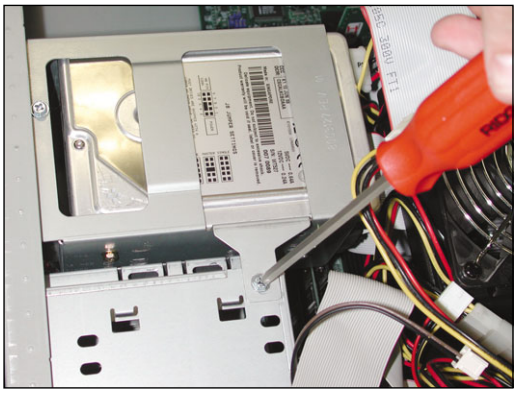
While we thought two 3.5-inch floppy drives and a SCSI tape drive looked a

Super Size Me!

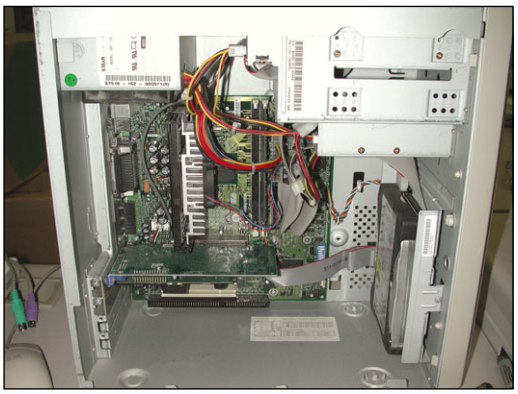
The Gateway E-5200's CPU fan was big—really big. Our forte is building PCs, but we almost considered using this fan to make a single propeller airplane. The particular arrangement of components in the case made adding extra hard drives and memory virtually impossible. Removing the fan and its mount helped immensely.

Four plastic plugs secure the fan to the mount. We used a screwdriver and depressed the plugs until we released the fan. The fan mount itself is actually mounted to another mount which also secures the CPU in its slot. Arrows on the fan mount indicate which direction to apply pressure that will release it. It isn't as easy as removing heatsink-and-fan combos on today's CPUs (in fact, it's very difficult to remove the heatsink from these old slot-style processors without damaging the processors), but we were able to do it without any trouble. ▲

little odd, we also had three potential places to mount the third hard drive. We quickly ruled out using the lowest bay because our memory modules would have blocked the hard drive's IDE pins. When we tried to mount the hard drive in the bay right below our optical drive, we ran into more problems with our IDE cables. When we replaced our SCSI tape drive with the third hard drive, the hard drive's screw holes didn't properly match up with the drive mount. We ended up using the Optiplex GX1's case screws to jury-rig the hard drive to the SCSI tape drive's old mount. It was a tight fit, but Frank finally accepted our extra memory modules and hard drives without complaining too much.



One screw attaches the E-5200's hard drive cage to its drive bays, while two others (one not pictured) secure the cage to the chassis.



The EMonster500 made excellent use of space, but its relative lack of PCI slots and hard drive bays quickly ruled it out as the case of choice.

Slaving away. Before we installed the hard drives and DVD-ROM drive in the case, we made sure that our master/slave jumpers were properly set. When two IDE devices share the same controller, one must be the master and the other is the slave. Most hard drives and optical drives include a diagram to show you where to position the shunt. We set one hard drive and the DVD-ROM drive to master.

A whim and a prayer: installing Windows XP. Each of our computers alone would have been sorely taxed trying to run WinXP, but we held out a faint hope Frank was up to the task. We glanced over our cables one last time, crossed our fingers, and pressed the Power button for the first time. When Frank roared to life (with that giant CPU fan running, we mean "roar" literally), showed a POST (power on self test) screen, and recognized all of our memory, we knew we were in good shape. We were a little surprised we didn't need to change any BIOS settings.

We restarted Frank with a WinXP installation disc and entered Windows Setup when we were prompted to press any key. After Windows Setup loaded some initial files, we pressed ENTER to start a fresh installation. We pressed F8 and were pleased to see Windows Setup recognized all three of our drives at their proper storage capacity.

When we tried to install WinXP, a mild calamity ensued: Frank inexplicably died while Windows Setup was formatting our C: drive to an NTFS format. Our initial reaction was that we had pushed the measly 200W power supply too far, but we were relieved to find that the ATX power connector had simply become loose. We pressed it back into place, and Frank was alive and kicking again.

After our minor setback, we experienced more problems formatting our hard drives. For some reason, Windows Setup wouldn't completely format either our C: or D: drives. With one chance left, we turned to our E: drive for salvation. Much to our relief, Windows Setup formatted the E: drive without issue. When WinXP started for the first time, it indicated our C: drive had a FAT32 format and our D: drive had an NTFS format. We still couldn't format the two drives, but we were able to move files to and from all of our hard drives; it seemed as though we could still use every drive.

We go crazy. At this point, Frank was running WinXP without any noticeable problems. We thought this fact alone was a small victory, especially when we considered these computers were probably made when WinXP was still a glint in Bill Gates' eye. But we wanted more. With all of our extra monitors lying around, it was silly to let them go to waste.

We started by setting up a dual-monitor system, which is relatively easy to do using WinXP. You'll either need a graphics card that supports two monitors or two separate graphics cards. We had two AGP graphics cards, but obviously our mobo only had one AGP slot. We were able to scrounge up an old PCI graphics card that didn't come from one of our PCs, so we have to admit Frank wasn't exclusively built using garage sale components. But once we had our dual-monitor system running, we think you'll agree our little transgression was worthwhile.

We shut down Frank, installed the NVIDIA TNT2 PCI graphics card in an open PCI slot, and connected our second monitor to the NVIDIA card. When we restarted our computer, the second monitor was still blank. This is normal. We thought it would be a good idea to download drivers for our two graphics cards, but we didn't have drivers for our Ethernet card either. Using a spare NIC solved the problem. Frank now had Internet access.

After we visited ATI's and NVIDIA's Web sites and downloaded drivers for each of our graphics cards, we restarted Frank to allow the new settings to take effect. Once we restarted WinXP, we right-clicked the Desktop and clicked Properties. We clicked the Settings tab, and two small squares labeled 1 and 2, respectively, appeared in the dialog box. We clicked Identify to know which monitor WinXP labeled 1, and vice versa. Then, we clicked one square and dragged it to match our monitors' physical arrangement. We

System Notes	
Physical Description	
Height	18.8 inches; 47.8cm
Width	7.1 inches; 18.0cm
Depth	16.1 inches; 40.9cm
Form Factor	ATX
System Specs	
Motherboard	Tyan Patriot 440BX Motherboard; Intel 82443BX Chip; Supports 100MHz Max. FSB; Four DIMM Slots Supporting Max. 512MB PC100 RAM; Two IDE Controllers; Two USB 1.1 Ports; Four PCI Slots (One Shared); Two ISA Slots (One Shared)
CPU	Intel 550MHz Pentium III, 100MHz FSB
Memory	320MB (128+128+64) PC100 RAM
Hard Drives	26GB Combined Storage (12+8+6)
Video Cards	16MB ATI Rage Pro AGP Card
	16MB NVIDIA Vanta PCI Card
	2MB Triton Microsystems PCI Card
Operating System	Windows XP Home SP1
Performance	
3DMark03	N/A
PCMark04	N/A
Outstanding Features	Triple Monitor System, capable of playing DVDs, more memory than most entry-level PCs, able to run WinXP and Office 2003
Weakest Links	No CD-RW Drive, some components scavenged from spare parts, crummy speakers
Summary Remarks	This is an old, yet nevertheless versatile system that causes others to both turn and scratch their heads. It makes an excellent weekend project for anyone who would otherwise throw away his old PCs.

clicked the Display drop-down box and selected the monitor that we connected to the NVIDIA card. We adjusted the Screen Area slider and Colors to match the settings of our ATI card. We clicked the Extend My Windows Desktop Onto This Monitor checkbox, Apply, and OK.

With our dual-monitor system up and running, we tried to do the ludicrous and make Frank into a triple-monitor screen. After we were fairly certain our dual-monitor system was stable, we shut everything down and installed the Jaton graphics card in an empty PCI slot. When WinXP restarted, it automatically provided us with generic drivers that seemed to work with the Jaton graphics card. This turned out to be a blessing because both Jaton (the card manufacturer) and Triton Microsystems (the GPU manufacturer) had broken links to their online driver Web sites. We repeated the process we used for a dual-monitor system to make a triple-monitor system.

Lady Luck was on our side with the Jaton graphics card, but she quickly abandoned us when we tried to use the ISA sound card. After numerous attempts to install the card, we gave up and turned to one last cheat that would give Frank a voice: an old spare Sound Blaster card. We removed the SCSI controller from our last remaining PCI slot (our two graphics cards and NIC occupied the other three slots) and installed the sound card. Once again, WinXP used generic drivers to get our sound card working.

Free software for Frank. Now that Frank had three monitors, we were ready to take advantage of the extra screens. We downloaded UltraMon software, an application that enhances multimonitor systems, from www.realtimesoft.com/ultramon. With UltraMon, we were able to run a different screen saver on each monitor, extend our wallpaper across three monitors, and have a different wallpaper on each monitor. To make our triple display extra appealing, we Googled "multimonitor wallpaper" and found numerous wallpapers specially designed for multimonitor systems.

We downloaded a free DVD player from www.cliprex.com so we could have a DVD decoder for Windows Media Player 9. With everything in place, we were ready to throw the laboratory door open and unleash Frank on the world.

Testing

In reality, simply installing WinXP on Frank was itself a test. Running today's benchmarks probably wouldn't yield worthwhile information, so we focused on testing Frank in a more qualitative manner. We wanted to see if our monster PC could take advantage of the multitasking possibility a triple-monitor system offers.

We started playing "The Matrix" and added more running applications until the movie no longer played well. Things were off to a bad start when the movie was jerky without any other apps running in the background. When we utilized our dual-monitor system and moved the window to our second monitor (using the NVIDIA card), the movie instantly became more watchable. Accordingly, we were pretty sure the ATI card that came with the Gateway E-5200 wasn't meant for viewing DVDs.

As we kept "The Matrix" playing, we opened Internet Explorer for a little casual Web browsing. Although the movie jumped a little bit, it seemed to catch up after a few seconds. Still, we'd prefer to leave Frank's CPU untaxed for future DVD sessions. We should also point out that when we tried to combine our monitors to watch the "The Matrix" on a giant, widescreen display, Frank went haywire. We found that watching DVDs solely on the monitor using the NVIDIA card produced the best results. On the bright side, Frank handled multiple MS Office 2003 applications with ease, making this a practical, albeit antiquated, multitasking PC.

Final Remarks

In the end, Frank will always be more of a novelty PC than anything else. While we didn't have too many problems putting together a serviceable system from five separate computers, we certainly wouldn't have made this a serious endeavor in any real-world situation. Don't misunderstand us: Our triple-monitor, DVD-playing, monster PC was better than any of the individual systems. If you have a pile of old computers taking up space in your garage, see what you can assemble. The results might surprise you. RS

By Vince Cogley

Build A Portable PC From Used Parts

We Burn Our Wallet & Build A New Notebook

Build #40 Skill Level: 1 2 **3** 4 5 ***Journeyman***

It's not unusual for a PC enthusiast to piece together a desktop computer from used parts, but even many hardcore users never attempt to fashion a notebook PC from components that have already been around the block a few times. There are a number of reasons so many veterans avoid this task.

Many believe that building a notebook is too difficult or that it's impossible to customize a system because notebooks require so many proprietary parts. Neither of these beliefs is entirely true. We discovered that building a notebook from used parts is actually pretty easy once you have the correct parts on a worktable in front of you. And mixing and matching parts from various companies, whether the parts are all from one company or several, isn't completely unworkable.

When we began, however, all we knew was that we wanted to build a notebook from used parts we found scattered at retailers across the Web. Users who are contemplating piecing together their own portable systems can learn from our experiences.

Goal

Our mission for this article was twofold. First, we wanted to find out how feasible it was to build our own notebook by buying used parts online. Second, we wanted to figure out whether it made sense financially for users to pursue such a project. To keep things as flexible as possible, we intentionally avoided setting a budget that might limit our ability to complete the task.

Background

We set out to find the many components we needed to build our notebook, and we immediately learned that while there are hundreds of Web sites devoted to helping users build desktop systems, notebook-building sites are a rarity. And although there are plenty of places to buy desktop computer parts, there are relatively few companies that cater to users who like the challenge of notebook construction.

That meant we had to scrape together a parts list from various Web sites and then find trustworthy retail sites that actually had the components in stock. This proved difficult on a number of counts. We didn't have too many problems locating lists that told us the kind of parts we needed for certain notebook models, and we were fortunate when we located a site that sold some of the parts we needed, but invariably, no single site had all the parts for a specific model. As a result, we wound up with several parts lists that were theoretically complete, but in reality, the components simply weren't sold by any dependable vendors.

We finally settled on a super-popular notebook model that seemed to have plenty of spare parts floating around on the Web. We picked a Dell Inspiron 8000, which at one point was the crème de la crème of notebooks, but as of this writing, was quickly fading into the obscurity of obsolescence. Still, parts availability was a major factor in the kind of components we chose for our notebook project. Users who can locate parts through eBay and similar auction sites will have much more flexibility during their shopping expeditions, and they may find more competitive prices than we did, too.

Covering the bases. Once we settled on a model that had plenty of available parts, we had to figure out exactly which components we really wanted. Unlike desktop machines, which obviously need a standard range of basic parts such as a case, motherboard, CPU, RAM, and more, notebook computers are specially

System Notes
Intel Pentium III 900MHz
30GB Toshiba Slimline Hard Drive
512MB PC100 SODIMM SDRAM
Dell Modular 8X CD-RW/DVD
15-inch LCD Monitor
Total Weight: 7.8 lbs
Performance
Sandra File System Benchmark: 22MBps
CPU Arithmetic Benchmark: Dhrystone ALU 3082 MIPS Whetstone FPU 1195 MFLOPS
CPU Multimedia Benchmark: Integer x4 iSSE 7831 iterations per second Floating-Point x4 iSSE 9308 iterations/sec
Cache & Memory Benchmark: Combined Index 1,326MBps

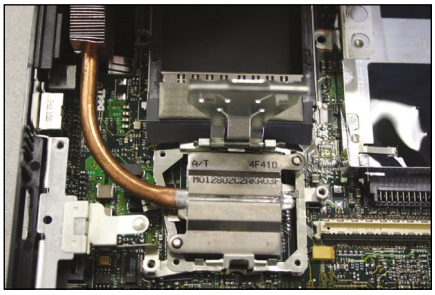
designed with customized components and nonstandard parts.

We decided to start with what we figured was the most important part of our notebook—the plastic shell that would encapsulate and protect our delicate electronics. As we soon learned, notebook cases aren't like desktop cases, because while desktops are just one or two large pieces of metal and plastic, notebook cases are more like jigsaw puzzles, and it's possible to buy different pieces of the puzzle from multiple sources.

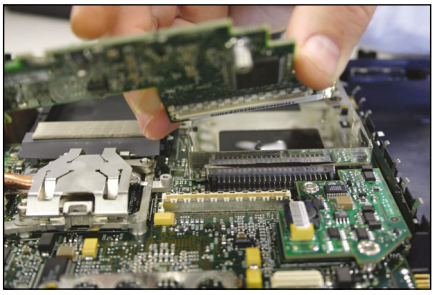
To keep confusion to a minimum, we bought a complete plastics kit from an online retailer. This kit came with everything we hoped we'd need, including an LCD cover, 15.1-inch bezel, palm rest, base, and power bar. Unfortunately, the price we paid here didn't include a keyboard. We found this part sold separately at a different site for $85.

Our next goal was to find a motherboard that would fit inside the case we bought. Because we went with the Inspiron case, we needed an Inspiron motherboard. We located just such a motherboard, with specs that claimed support for a processor as fast as 1GHz.

We pulled apart our empty notebook case, making it easy to insert the motherboard and other vital parts.



The heatsink slipped over two posts on either side of the CPU. The CPU bracket went over the top of the heatsink and CPU.



The video card plugged into the connector near the CPU socket. We used several screws to make sure this card stayed put.

Because we didn't have much choice in the matter, this was the board we selected.

Notebook video cards have always lacked power, and we certainly couldn't jam ATI's newest desktop card onto our tiny motherboard. Our choices were limited to either a 16MB NVIDIA card or a 32MB card that cost slightly more. We made the obvious choice by buying the beefier of the two.

It was also challenging for us to find an appropriate CPU to match our Inspiron motherboard. We couldn't locate a 1GHz CPU for a reasonable price (or from a reliable-looking site), so we opted for a 900MHz Pentium III CPU instead. You might wonder why we picked a processor that's so far past its prime, but once you do a little looking for notebook CPUs, you'll understand that these processors don't come cheap. And of course, upgrading to a Pentium 4 would have forced us to give up on the Inspiron 8000 components, find a site that offered newer parts, and spend much more money to complete the project.

We did get to do some splurging. When it came time to choose RAM modules, we couldn't see sticking with only 256MB when we'd already invested in a too-slow processor and a video card that would be worthless for Far Cry. So instead of settling for less, we doubled our RAM to 512MB of PC100 SDRAM, hoping this buy would give our system a much-needed power boost.

To make sure our notebook was as adaptable as possible, we wanted an optical drive with a full range of capabilities. That meant forgoing a typical CD-RW drive for a drive that also had the ability to read DVDs. After checking the options available for the Inspiron 8000, we chose a modular 8X CD-RW/DVD drive.

Finishing touches. Our system was pointless unless we found an LCD to slip under the plastic screen cover. Notebook LCDs are often incredibly expensive, and depending on where you buy one, they can consume one-third or even half of a notebook's entire budget. We eventually found a reasonably priced 15-inch LCD that came complete with a cable and hinges; these last two details are worth noting because there are a lot of retailers who sell stripped-down LCDs that can't be installed until you have the bits and pieces necessary to make them work.

We spent far less time shopping for a hard drive. We didn't need anything special for this portion of our machine, just a dependable, easy-to-install drive with moderate capacity. For less than $120, we snagged a 9.5mm slim hard drive with 30GB of space for our various programs and files.

Unlike desktop machines, which we could've assembled using screws we found lying on the floor of our hardware lab, notebooks require perfectly matched screws to make sure each and every part fits securely. In other words, we couldn't steal a few drive screws from our co-workers and call it good. Instead, we invested in a screw kit from an online store.

Once we finalized our parts list, we had blown hundreds of dollars more than we first expected to spend on this particular system. Users who want to construct their own notebooks will definitely want to take advantage of eBay to access lower parts prices.

The Build

Putting together our notebook was actually much easier than trying to find parts online. We assembled our machine in about 30 minutes with very few problems.

We started by pulling out our plastics kit and opening it up on our clean work surface. Our case was basically a hollow shell, nothing more than a plastic and aluminum

chassis for mounting various components. After extracting the motherboard from its antistatic bag, we lowered the board into the case, carefully pushing and pulling the case's various plastic posts and frames to help the board settle into its new home.

With our motherboard in place, we used a screwdriver to open the bracket securing the heatsink to the CPU socket. We pulled out the heatsink, dropped the CPU into its pinholes, rested the heatsink on top of the die, and closed the bracket to secure these components.

Then we opened our video card and located the appropriate connector on the center of the motherboard. The video card snapped neatly into this connector, and we used M2.5 x 8mm screws to secure it to the motherboard.

Our system was looking pretty exposed, so next we grabbed our palm rest, which already had a touchpad built into it. Installing this plastic piece was easy, as we just aligned it with the case bottom outside frame, lowered it, and snapped it into place, making sure the touchpad's connector dangled out from under the palm rest. We took this plug and connected it to the motherboard connector immediately above the touchpad.

Next, we decided to install our LCD. Because we'd ordered a complete plastics kit and a preassembled LCD monitor, we actually had an extra cover for the back of the display. We opted to go with the assembled monitor, so to remove the preinstalled (but vacant) display cover, we popped out the hinge cover and lifted it off the case. Then we lowered the hinges of the complete LCD into the appropriate slots. We connected the LCD's ribbon cable to the top of the video card and used an M2.5 x 6mm screw to affix the strain relief assembly (in the middle of the video cable) to a hole near the middle right of the case chassis.

To wrap up this part of the assembly, we took the hinge cover, which was basically a long strip of black plastic complete with the power button and indicator LEDs, and snapped it into place under the display. We had to push the display all the way back to make enough room for this task.

After securing the hinge cover, we very gently lifted the keyboard, tilted it so we could attach its data connector to the middle of the motherboard, and slid it into the metal tabs on the left side of the case chassis. Then we lowered the right side of the keyboard and pressed down to snap it into place. We found that the key caps tend to fall off the board with the slightest of bumps, but fortunately, they're also easy to wiggle back onto their foundations.

Then it was time to insert the screws into the bottom of the case. We closed the display and carefully flipped the system. For each screw hole that was labeled with a P (for palm rest) or K (for keyboard), we used a 20mm screw. These screws were critical for helping to keep the system together while we finished up our other tasks.

We didn't insert a screw into the compartment with K/M and C screw holes. Instead, we opened this compartment to reveal the RAM slots. To install our modules, we slid them into the brackets and pushed down to snap them into place. If we'd had only one RAM module, we would've used the A slot to make sure the computer recognized the memory. Then we closed the compartment and screwed down the door.

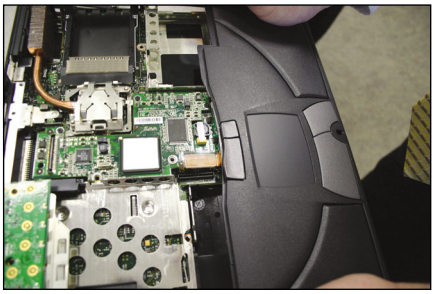
With our system almost complete, we flipped it over again and inserted the battery and modular CD-RW/DVD drive. We pressed our hard drive's included adapter onto its pins and dropped it into

Parts List

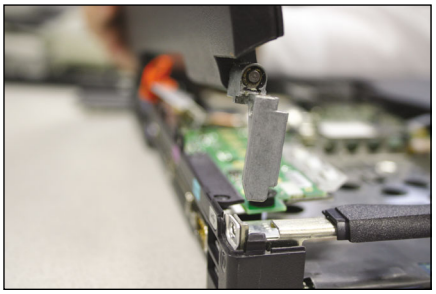
Building a notebook from used parts can be an economical way to get your hands on portable computing power—but only if you buy wisely. As you can see, buying components from many different vendors (who mark up prices on aging notebook parts) made this an expensive project. Using eBay or another auction site would've dropped total costs significantly.

Component	Model	Price
Case	Dell Inspiron 8000 Plastics Kit	$145
Motherboard	Dell Inspiron 8000 Motherboard	$329
Processor	Intel Pentium III	$109
Memory	PC100 SDRAM SODIMM	$180
Hard Drive	Toshiba Slimline Hard Drive	$119
Video Card	NVIDIA 32MB	$79
Optical Drive	Dell Inspiron 8000 Modular 8X CD-RW/DVD Combo	$139
Monitor	15-inch Preassembled Inspiron LCD	$349
Keyboard	Inspiron 8000 Keyboard	$75
Operating System	Windows XP Home Edition	$90
AC Adapter	Dell Inspiron	$40
Ethernet/Modem	Xircom Realport 56K Modem and 10/100 Ethernet	$39
Heatsink	Dell Inspiron 8000 Heatsink	$32
Battery	Dell Inspiron 8000 Li-Ion Battery	$85
HDD Caddy	Dell Inspiron 8000 Drive Caddy	$16
Miscellaneous	Dell Inspirion 8000 Screw Kit	$19
Total		**$1,845**

NOTE: Tax and shipping costs are not included.



The palmrest simply snapped into place below the video card.



We lowered the LCD hinges into the slots on either side of the motherboard chassis.

the hard drive caddy with the label side visible. We screwed the drive to the caddy, slid it into the drive bay in the computer, and used a screw to make sure the drive stayed put.

Testing

We flipped our notebook, plugged in the AC adapter, and pressed the power button. The LEDs on the front of the machine flickered hopefully and then went dark again, with the exception of the battery-charging LED. We tried again and again, but the system simply would not even begin to start.

Perplexed, we reviewed a few notes for building Dell notebooks. Then we found one problem. We hadn't turned the CPU locking screw after we dropped the processor into its socket. After uninstalling a few parts to access the CPU, we found this screw, which was clearly marked next to the socket, gave it a quick twist, and reassembled the PC.

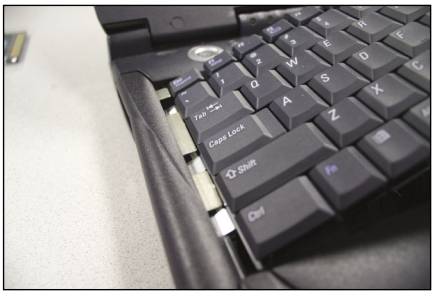
We held our breath and pressed the power button. This time, the computer sprang to life and displayed the BIOS revision (A23). We pressed the F2 key to enter the BIOS menu and then we pressed the ALT-P keys to access the Boot Order menu. In this menu, we used the U (for up) and D (for down) keys to change the boot order so that the optical drive started first, and the hard drive second.

We inserted our Windows XP installation disk and chose to install the OS on our C: drive. We didn't create any partitions, and we used the NTFS Quick option to format our drive and begin the basic file installation. About 30 minutes later, we had a full version of WinXP in place.

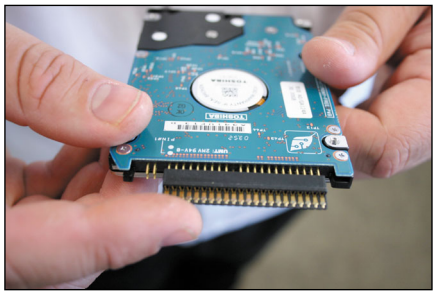
One problem was the size of the programs as they appeared in Windows. Each program used only about 5 inches of the screen, making it difficult to perform any tasks. We right-clicked the Desktop and increased the display's resolution to 1,600 x 1,200. Because of the way some Dell notebooks handle resolution, this command forced our applications to fill the entire display.

With most of the desktop systems we have built, we have had to install numerous drivers to rid ourselves of the yellow exclamation points in Control Panel. For our notebook, we didn't have to perform any driver updates. Each system component worked correctly after we installed WinXP. Because we'd decided to use a PC Card with Ethernet, modem, and USB capabilities, we slipped it into a slot, and the OS immediately recognized each device.

With our system running smoothly, we decided to run benchmark programs to see how well our collection of used components would handle a little heat. Unfortunately, we weren't able to run PCMark04 or 3DMark03 because these programs require a processor with a minimum speed of 1GHz. As a substitute, we installed and ran several of the benchmark utilities included in SiSoftware Sandra, and you can see the results in our System Notes sidebar.



We slipped the keyboard into the left side of the chassis first, and then we carefully pressed down on the center and right side of the keyboard to secure it.



The necessary hard drive adapter connected to the drive like this. Then we screwed the drive to its caddy and slipped it neatly into its bay in the notebook.

Watch Out

Many of Dell's notebooks use a CPU locking screw. You must tighten this special screw to lock your CPU into place; otherwise, your computer won't boot. ▲

Time-saver

If you decide to put together your own notebook, pick a formerly popular model that's about two to three years old. This ensures that you'll find plenty of available parts online. If you choose a newer or older model (or a model that never sold particularly well), you might have a difficult time finding components, or you might pay too much for the parts you can actually locate. ▲

Final Remarks

It goes without saying that notebooks need parts similar to those that go into desktop machines, so if you've assembled a few desktops, you won't have many problems building a portable version. Parts shopping really will be one of the more difficult aspects of this project, and you'll have to be attentive as you buy to avoid getting gouged.

Our PC cost nearly $1,900 to build, and that didn't include shipping costs; a used Inspiron 8000 might sell for about $500 on eBay. In other words, buying a prebuilt used PC is your best bet for cheap portable computing, and purchasing used parts from retailers is probably the worst option available.

However, shopping for used parts on eBay is still an option. You'll have to keep an eye on shipping costs and start looking for components as soon as possible. It might take you a few weeks to locate appropriately priced parts that will give you the power you want, but once you have every component you need, it won't take you long to build a customized notebook with all the trimmings you care to buy. RS

by Nathan Chandler

CREATE A UNIVERSAL INPUT/OUTPUT SYSTEM

Got Media? This Machine Knows What To Do With It

Build #41 Skill Level: 1 2 **3** 4 5 ***Journeyman***

This is a view of the front panel of our Universal Input/Output System.

Building a system to act as a universal translator is a complicated undertaking, especially given the ever-evolving standards technology is prone to. Although backward compatibility lessens the sting of constantly changing technologies, many high-tech manufacturers continue to develop proprietary standards in the hopes that their products will become the next compact disc.

Goal

The purpose of this project was to build a system that can take any input data and let us play, hear, view, decode, encode, zip, send, save, print, and manipulate it to our media-loving heart's content. This universal input/output system has to handle most forms of popular media, such as audio CDs, CD-ROMs, CD-RW, DVDs, DVD-RWs (-; +), diskettes (3.5-inch, 5.25-inch), CompactFlash, Smart-Media, Memory Stick, MultiMediaCards, SD (Secure Digital), Microdrives, Zip (100, 250), and MiniDisc, as well as readily accept USB 1.1 and 2.0, 802.11a/b/g, Ethernet, 32-bit and 64-bit software, FireWire, Bluetooth, FM Radio, CATV, VIVO (video in, video out), DVI, and VGA.

Background

In order to rightly call our machine a universal translator, we built our system around AMD's 1.8GHz Athlon 64 2800+ for its ability to simultaneously process 32-bit and 64-bit applications. The motherboard for this system needed to have plenty of USB ports, FireWire ports, and support for several IDE devices. Gigabit LAN was a priority, as well as several PCI slots. We also wanted a board that supported AMD's HyperTransport high-speed bus technology and plenty of RAM. We settled on ASUS' K8V SE Deluxe, the self-crowned King of Athlon 64 motherboards. Our system had to be able to communicate with 802.11a, b, and g networks, so we went with a Linksys 54Mbps dual-band wireless A+G PCI Ethernet adapter. We chose a 1GB dual kit of Kingston PC 3200 memory (the K8V SE Deluxe supports up to 3GB). The video card we chose was the NVIDIA GeForce Personal Cinema FX5700 with 128MB of dedicated DDR, which supplied our system with FM Radio, CATV inputs, VIVO, and DVI output. An adapter gives us VGA support, and the audio/video breakout box supports component video, S-Video, composite video, and stereo audio inputs and outputs.

The case we chose was a Lian Li mid-tower with a brushed black finish, which featured four 5.25-inch drive bays and three 3.5-inch bays. The three internal 3.5-inch bays were sufficient for our hard drives. The case also included an 80mm rear exhaust fan, which is suggested by AMD's Web site. Lian Li threw in two more 80mm fans to cool the internal 3.5-inch drive bays. We picked up a reasonably inexpensive Allied 400-watt PSU to power our components. We needed a way to view our output, so we bought a recertified IBM G78, which is a 17-inch CRT monitor with a flat black shell. We chose the Desktop MX Bluetooth-enabled keyboard and optical mouse combo from Logitech to give us an additional wireless technology. To enjoy our digital media, we bought the Altec Lansing 251, which is a budget 5.1 speaker system.

Our optical drive comes in the form of Plextor's 8X DVD-RW/+RW drive. In an effort to make the most efficient use of our external drive bays, we chose an Adaptec 7-in-1 media reader that reads 3.5-inch diskettes, CompactFlash, SmartMedia (up to 128MB), Memory Stick (up to 128MB), SD Memory Card, MultiMediaCard, and Microdrive (340MB or 1GB). With a nod to yesteryear, we even bought a 5.25-inch floppy drive. We also included a Zip drive that handles 250MB and 100MB disks. We bought two identical Samsung 80GB SATA hard drives, which we can use with either of our K8V's RAID controllers.

We chose Windows XP Home as our OS. We also included Quick View Plus 8, an application that allows users to view, copy, and print virtually any graphic, document, database, presentation, or Zip file.

We also bought a Sony Net MD Walkman MiniDisc player, as well as a 25 pack of DVD+R recordable discs. Our budget for this system was $2,000, and we slid in with enough change left over to buy a 12-pack of Mountain Dew, so crack open a cold Dew and let the build begin.

The Build

Before handling any piece of computer equipment, we made sure to diffuse static electricity. Touching a grounded piece of metal or wearing an inexpensive antistatic wristband can protect your sensitive components from frying before you even get a chance to see them work. The next thing we did was familiarize ourselves with the motherboard and browse the manual. After taking stock of the various parts, connectors, and accessories, we turned our attention to the processor.

When mounting your hardware to the motherboard, it is a good idea to work on a clean, flat surface. We used the sheet of foam that came with the mobo to cushion the bottom of the board while we worked on it. The Athlon 64 2800+ PIB (Processor In a Box) included an aluminum heatsink and fan assembly. First, we lifted up the K8V's socket-locking arm to a 90-degree position. The Athlon 64 has a small, gold triangle at one corner that corresponds to a triangle on the socket. We lined them up, and the CPU slid in place with minimal force. Next, we locked the socket arm down.

The heatsink has a plastic sleeve that protects the preapplied patch of thermal paste. An uneven or scratched patch of thermal paste will result in an inefficient heat transfer between the processor and heatsink, which could damage the CPU. Our motherboard came with the retention frame and backplate already in place, but the Athlon 64's installation instructions detail the mounting process if your board wasn't preassembled. We removed the plastic cover that protects the thermal paste patch and positioned the heatsink over the processor. With the cam lever in the unlocked position, we lined up the metal spring clips on the heatsink with the plastic mounting lugs of the retention frame. We pressed on the metal spring clip just below the cam lever until it locked into place. Next, we pressed on the opposite spring clip until it locked to the retention frame on the opposite side. This may take a bit of pressure, but be aware that undue pressure can break the board or damage the processor. Always apply the pressure to the metal spring clips, not the fan assembly. With the heatsink installed, we turned the cam lever and locked it into position as per the instructions. Finally, we plugged the CPU fan plug into the corresponding leads on the motherboard.

We bought two sticks of PC 3200 DDR RAM in a kit, which means they are identical modules. The K8V SE Deluxe doesn't support dual-channel memory, but paying an extra couple bucks for identical modules is not a bad idea. Again, we made sure we were grounded and positioned the first module in the blue slot labeled DIMM 1. The module is notched and will only fit into the slot one way. With the ejector tabs open, we pushed the module into place one edge at a time until the tabs locked into place. We followed the same procedure for the second module using the yellow slot labeled DIMM 2.

Our next task was to install the motherboard to the mounting plate in our case.

Our system will accept all this media and more.

Parts List

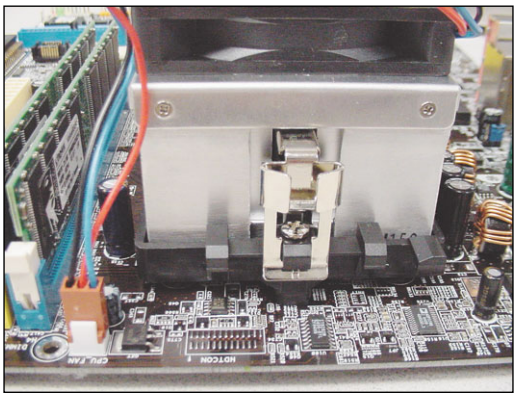
Component	Item	Price
Case	Lian Li Black Mid-Tower Case, PC-78B USB	$95
Monitor	IBM G78 1,280 x 1,024 17-inch Flat Black Monitor (Recertified)	$90
PSU	Allied 400W Power Supply	$35
Mouse/Keyboard	Logitech Cordless Desktop MX for Bluetooth	$160
Mainboard	ASUS K8V SE Deluxe	$123
CPU	AMD Athlon 64 2800+, 512KB L2 Cache (Fan And Heatsink Included)	$187
RAM	Kingston ValueRAM Dual Channel Kit 1G (512MBx2) DDR PC-3200	$181
Hard Drive	Samsung 80GB SATA Hard Drive (x2)	$158
Optical Drive	Plextor 8X DVD-RW/+RW Drive	$141
Floppy Drive	Teac 5.25-inch Floppy Drive FD-55GFR	$25
Media Drive	Adaptec 7500 Digital Media Reader/Writer	$70
Video Card	eVGA NVIDIA GeForce FX5700 Personal Cinema	$250
OS	Windows XP Home OEM Version	$64
Software	Quick View Plus	$40
Zip Drive	Iomega Beige Internal IDE 3.5-inch 250MB Zip Drive	$66
Speakers	ALTEC LANSING 251 5.1 Amplified Speaker System	$67
Misc.	LINKSYS 54Mbps Dual-Band Wireless A+G PCI Ethernet Adapter	$84
	RIDATA 8X DVD+R 4.7G Single Sided Write Once Media	$26
	Sony Net MD Walkman MiniDisc Player	$135
	12-pack of Mountain Dew	$3
TOTAL		**$2,000**

Hits & Misses	
Outstanding Features	This powerful system has the ability to work with more than 12 kinds of recordable media; supports various wireless technologies; and allows you to view hundreds of file formats, watch and record TV, and enjoy DVDs with surround sound.
Weak Links	Unfortunately, the King of Athlon 64 motherboards had a pauper's ability to run both of our floppy drives. With a little more money, you might want to get a standalone sound card and faster processor.

We removed both side panels from our case chassis and positioned the motherboard in the case, lining up the holes on the mobo with the holes in the mounting plate. From the back of the plate we could see the holes that would need standoffs. We marked the holes with a pencil and removed the motherboard. Our case uses snap-in spacers, so we pushed them through from the back of the mounting plate until they snapped into place. With the spacers installed, our next task was to position the motherboard over the spacers and screw the board to the case. Never tighten the screws too much, as this can damage the board. Most new motherboards come with metal rings that circle the screw holes, which negate the need for washers. The Lian Li midtower gave us very little room to maneuver our motherboard, but with some careful planning, we mounted the board in no time. Next, we turned our attention to the case components.

In addition to the rear exhaust fan, our Allied 400-watt PSU has a fan on the bottom to further instigate the transfer of hot air. The PSU only fits into the case one way. We used four bolt screws to secure the PSU to the case and let the cables dangle in front of the motherboard. We supplied power to the motherboard with both the 4-pin auxiliary connector and 20-pin ATX power connector. Next, we removed the rear expansion slot cover from the case that lined up with our AGP slot. After we made sure the connector lock on the AGP slot was open, we slid the NVIDIA GeForce FX5700 into the AGP slot and screwed the bracket to our case. We pushed the connector lock in place and connected a Molex plug from the PSU to the power input on the video card. The K8V motherboard came with a digital audio connector in the form of an S/PDIF out bracket, so we installed it in the uppermost expansion slot, just above the video card. The bracket connects to a three-wire lead on the motherboard labeled SPDIF_OUT, which happened to be below the video card. Luckily the wire was long enough to go around the video card while staying clear of the heat-producing elements and fan blades.

Some builders may prefer to load the OS before installing extraneous drives or PCI devices, but we chose to connect everything at once. We installed the Linksys 54Mbps dual-band wireless A+G PCI Ethernet adapter next, using the lowest PCI slot, in order to give the antenna room to move without interfering with our video card's cables. The card slid into the slot with little effort. Next, we installed the single-port FireWire module in the open slot below the video card. We connected the cable to the motherboard lead labeled IE1394_1. Our two Samsung 80GB SATA hard drives slid into the bottom two internal 3.5-inch bays. We made sure the connectors were facing the interior of the case while the front of the drives faced the two front-panel fans. Two screws on either side secured each of the drives. We chose to connect our drives to the Promise-controlled SATA ports, which are labeled PRI_SATA (primary) and SEC_SATA (secondary). We then attached the thin SATA cables to the drives and motherboard and supplied power to each of the drives with two SATA power plugs from the PSU.



Apply pressure to the metal spring clip, not the heatsink fan, or you might end up damaging your board or CPU.

We've found that it is easier to connect the floppy and IDE device cables before installing the drives themselves. We started with the IDE cable we planned to use on the optical drive and Zip drive. The ribbon cable we used was notched so it would only fit into the plug one way. We connected the ribbon cable to the notched plug on the motherboard labeled PRI_IDE and wrapped the excess cable around the PSU connectors to improve airflow. We installed the Zip drive in the middle external 3.5-inch bay and the optical drive in the bottom 5.25-inch bay. We installed our Adaptec 7-in-1 media reader above the Zip drive and mounted the 5.25-inch floppy drive above the optical drive. The media reader portion of our 7-in-1 drive required an internal USB connection, so we connected the 4-pin plug to the top five USB leads labeled 1 USB78. We used an old floppy cable that features both a slot for the circuit board leads of the 5.25-inch drive, as well as a more common 33-pin connector for our 3.5-inch drive and media reader. As luck would have it, our floppy configuration turned out to be a bit too ambitious, but more on that later. We then supplied power to each drive using the appropriate power connector from the PSU.

Our last task was to connect the case's power switch, reset switch, IDE and power LEDs, and internal speaker to the motherboard. This assembly of 20 leads is typically called the system panel connector. Most mobos label these leads, and a good case also labels the corresponding connectors. We matched the plugs with the diagram in the mobo manual and kept the plug labels facing outward. By doing this we were sure to get the plugs lined up with the proper leads. Next, we connected the rear exhaust fan to the power lead on the mobo and the front intake fans to the PSU. Finally, we connected the monitor, mouse, keyboard, and speakers to our system.

Testing

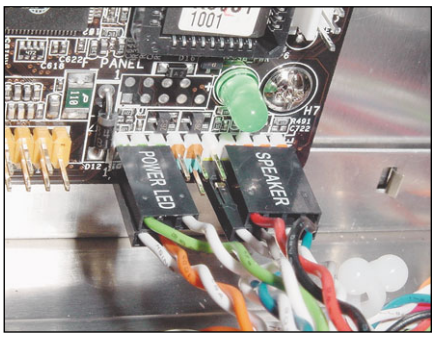
Before powering on, we did a thorough spot check of every wire, lead, device,

System Notes	
Price	Under $2,000
Operating System	Windows XP Home
Processor	AMD 1.8GHz Athlon 64 2800+
RAM	1GB PC3200 DDR SDRAM
Bus Speed	1600MHz
Hard Drive	160GB (RAID 0)
Optical Drive	Plextor PX708A 8X DVD+R, 4X DVD-R, 4X DVD+RW, 2X DVD-RW, 12X DVD-ROM, 40X/24X/40X CD-RW
Connectivity	802.11a/b/g; Bluetooth; Gigabit Ethernet
Peripheral Connectivity	2 FireWire; 6 USB 2.0
Video Card	NVIDIA GeForce FX5700 Personal Cinema
Video RAM	128MB
Monitor	IBM G78 17-inch CRT (Recertified)
Sound Card	Integrated audio
Speakers	5.1-channel Altec Lansing 251 speakers
Chassis Type	Mid Tower
System Use	Miscellaneous Media Reading/Writing

connector, slot, and cable to make sure everything that needed power was getting it; we tucked every loose wire away from exposed fan blades; and we made sure to set the PSU at 110 volts. We turned the monitor on first to let it warm up. Our motherboard's standby LED lit when we switched on the PSU, which was a good sign that the board was getting power. We pressed the power button on the front of the PC and watched to make sure the CPU fan was spinning. The system started by displaying the motherboard logo screen and then began scanning for devices connected to the VIA controller. Next, the system scanned the Promise controller for devices. After finding no connected devices, the monitor displayed the American Megatrends (the BIOS manufacturer) logo screen with the message, "No hard disk drive detected! Press F1 to resume." We pressed F1 and got the message, "Reboot and select the proper boot device or insert boot media in selected boot device and press a key."

Because we used SATA drives and connected them to the Promise RAID controller, we had to tell the PC to look for the Promise RAID array drivers on a 3.5-inch floppy drive. With a working computer, we explored the mobo support CD and double-clicked the Drivers folder. We double-clicked the Promise folder and then double-clicked 378RAID folder. Double-clicking the MakeDisk file loaded the necessary files onto a blank floppy.

With the WinXP Home disc in our new system's optical drive, we booted our PC and pressed DELETE to access the BIOS Setup Utility. Under the Boot tab, we designated the 3.5-inch floppy drive as our first boot device. We then used the arrow keys to move to the Exit tab where we selected "Exit and save changes." We powered the system up and, when prompted, pressed F6 to indicate that we wanted to install SATA devices. The next screen displayed the message, "Setup could not determine the type of one or more mass storage devices. . . ." At this point we selected the option to use a device support disk from a mass storage device manufacturer. When prompted, we inserted the disk and pressed ENTER. We then selected the Promise controller and designated that we wanted a RAID 0 configuration (striping) for our two Samsung drives. We chose "Format the partition using the NTFS file system." Once the formatting finished, we loaded WinXP and then drivers for the video card, media reader, and 802.11 wireless adapter.



The Lian Li case's system panel connectors are clearly labeled.

In the process of troubleshooting our 5.25-inch floppy drive, which wasn't showing up, we discovered that the K8V SE Deluxe's BIOS won't allow two floppy drives to be connected at once. A quick call to ASUS confirmed our suspicion that dual floppy support has been dropped from their newer boards. For the tiny minority of you actually interested in building a new system with two floppy drives, we suggest getting a mobo that supports dual floppy. Or, you can do like we did and set drive A: as the 5.25-inch drive, copy anything you can salvage from your old floppies to your hard drive, and then reinstall the 3.5-inch drive and set the BIOS accordingly.

The final test we performed was to take some data and juggle it around as much as we could. First, we used our Personal Cinema FX5700 to take a screenshot from "The Matrix" (one where Keanu Reeves looked particularly pensive or hungry—we're not sure which). Next, we copied the pic to our 5.25-inch drive, and after several loud clicks, we cut and pasted the file to the Desktop. We turned the system off and replaced the 5.25-inch floppy with our 3.5-inch floppy and media reader, making sure to set the BIOS accordingly. Next, we used a Bluetooth-enabled pocket PC to explore our Desktop and snatch a copy of the graphic. We then copied the file onto the PDA's SD Memory Card and transferred it back to our new translator via the media reader. We then copied Keanu to a Zip disk, CD-ROM, DVD-ROM, 3.5-inch floppy, CompactFlash card, MultiMediaCard, USB flash drive, and Memory Stick. Finally, we recorded Morpheus' "The Matrix Is All Around Us" speech as an audio file and ripped it to our MiniDisc player.

Final Remarks

This PC isn't the fastest you'll find, but it is quite adept at handling just about any form of media you can throw at it. If we had to build the system again, we'd choose a different mobo that allowed for multiple floppy devices and dual-channel memory, just for the boost in speed. If your budget is flexible, you might want to splurge on a faster processor, such as the Athlon 64 3200+, or a standalone sound card. With less money to spend, we'd recommend dumping half of the RAM, and an adequate case can be had at half the price of our Lian Li. For those of us unwilling to pick and choose among media formats, this system will do a fine job of staving off obsolescence—at least for a little while. RS

by Andrew Leibman

Assemble An Apple/Windows Hybrid Machine

Give A Mac A Window To The PC User's World

Build #42 Skill Level: 1 2 3 4 5 **Novice**

Those of us who use both Windows and Mac OS applications know that most files are compatible with both OSes. However, most programs run on only one OS or the other. For the user who can't live without either OS, a hybrid system is the way to go, but many people don't know that there is a way to run both Windows and Mac applications on the same computer.

Goal

The system we would build not only would run both Windows and Mac OS, but it would also run both operating systems simultaneously. This was because we wanted to copy excerpts of documents from Mac-based applications to Windows-based applications.

Our goal was to build a system that would integrate the Windows and Mac environments seamlessly enough that switching between Mac and Windows applications didn't feel like stepping foot in a foreign country.

We did not include a monitor in the cost of our system because we used an LG Electronics 15-inch LCD we already had on hand. Had we added an Apple LCD, we would have spent at least $699 (the starting price for an Apple screen).

Background

We considered a variety of ways to build this machine, but in the end, the only choice was to make this a software-based rather than hardware-based system. This is because Windows PCs are based on the x86 CPU architecture, while Macs are based on the PowerPC architecture, making it impossible for the same software to run on both systems, except through emulation.

We searched for Mac and Windows emulators. Our first choice would have been to build a PC and run the Mac OS on it, but until recently, Mac emulators were for pre-OS X systems. For our system, we wanted to run modern applications for both Windows and Mac, so we really needed an emulator that could run modern Mac applications. We felt the emulator should be able to handle OS X applications that were designed for use with a G3 or faster processor.

There is now a PowerPC emulator called PearPC (pearpc.sourceforge.net), but at press time, it is still in its infancy. As recently as May, the software's authors stated on the PearPC site, "Please note that this is an experimental program not meant for productive use. There are still unimplemented instructions, mysterious bugs and missing features. Don't use it on important data; it WILL destroy them sooner or later!"

Since that time, PearPC has undergone a number of improvements and gained a devoted following. A Google search for PearPC returns many sites devoted to PearPC use and development. However, it is still a work in progress, and a PearPC system runs at approximately 1/40 the speed of the actual installed processor. In the future, though, PearPC may be a reasonable way to run both Windows and Mac OS on one machine.

For our system, we decided to go the safer route and emulate Windows on a Mac. We bought a 1.25GHz Power Mac G4 and a copy of Microsoft's Virtual PC 6.1, an x86 emulator. To learn more about Virtual PC, see the "Macs Experience A Virtual Reality" sidebar on page 181. At press time, Microsoft hadn't released Virtual PC 7 yet. The new version will support G5 Macs, but Virtual PC 6.1 only

supports G3 and G4 processors. Our Virtual PC copy included Windows XP, but Virtual PC is also available separately.

We were concerned about the strain Windows might place on the system's memory, so we added an additional 1GB of DDR SDRAM beyond the base 256MB of PC2700 DDR that comes with the system. Our system also featured an 80GB 7,200rpm hard drive and an extra drive bay. This would ensure that we could add more storage, a likely scenario because we planned to use programs and files for both Mac and Windows on the same machine.

The computer has DVI and ADC (Apple Display Connector) ports for attaching a monitor, and it comes with a DVI-to-VGA adapter. We used an LG Electronics LCD we had on hand from another system.

Finally, we bought a pair of antivirus programs, one for Mac OS and one for the Windows emulation. It is important that you install an antivirus application for each of the OSes because Mac software will not protect the virtual Windows environment, and Windows software will not protect the Mac files. We chose Symantec Norton AntiVirus 2004 for Windows and Symantec Norton AntiVirus 9.0 for Mac.

The 1.25GHz Power Mac G4 does not have a VGA connector, so we had to use the provided DVI-to-VGA adapter to connect the system to our LCD monitor.

The Build

There was no real build process for this article because the system was already assembled. However, the system is highly upgradeable. We will describe setting up a Mac, how to upgrade the Mac's components, and how to set up and use Virtual PC.

To set up our Mac, we simply connected the power cord to the back of the computer and the surge protector. Before plugging in and connecting the monitor, we attached the DVI-to-ADC adapter that came with the G4. We connected an Ethernet cable to the Ethernet port and the keyboard to one of the two USB ports on the back of the computer. There is also one USB port on each side of the keyboard; connect the mouse to either.

If we want to upgrade this system in the future, it will be very easy. To open the case, you simply pull a ring at the top of the right panel of the case and lower the hinged right panel to the desktop. The inside of the case holds the hard drive and open bays for one more ATA/100 or SCSI drive and two bays for optional ATA/66 or SCSI drives. The hinged side panel holds the motherboard for easy access to its components and slots.

Additional memory and extra optical and hard drives install the same way as on a PC. Drive bays are very easy to remove. You just press a tab and pull the bay out. After inserting and securing the drive, you adjust the jumper settings and slide the drive bay back until it clicks in place. Then you connect the IDE and power cables.

The OS was preinstalled, and as soon as we turned on the computer, a setup wizard appeared. Setup was so straightforward that we won't bore you with a detailed account, except to say that it went very quickly and that when we were done, everything was configured, including the POP and SMTP servers for our primary email account. Before we proceeded, we clicked the Apple menu and Software Update to select, download, and install critical updates, such as OS updates and security patches.

If you use a router that blocks Internet access to unauthorized systems, you will need to enter the Mac's MAC address in your router-management software. To find the MAC address on a Mac, click the Apple menu, About This Mac, and More Info. From the list in the left pane, click Network. In the lower half of the right pane, the MAC address is listed, labeled as the Ethernet Address.

Terminology. Throughout the rest of this article, when we refer to "Virtual PC" with a capital "V," we are talking about the actual software we bought from Microsoft. When we refer to "virtual PC" with a lowercase "v," we are describing the "virtual" Windows-based PC that we ran on our Mac. For instance, we may discuss running the Virtual PC software but backing up our virtual PC's files.

Install Virtual PC and Windows. After setting up our Power Mac, we inserted the Virtual PC installation disc in the drive. The installation disc's startup window instructed us to drag the Virtual

Macs Experience A Virtual Reality

Although Virtual PC today bears the Microsoft name, originally, this software carried the name Connectix. This company released the first version of Virtual PC for Mac in 1997. Connectix also offered a Virtual PC program for Windows. This software did not emulate a Mac environment on a PC. Instead, Virtual PC let Windows users run more than one Windows OS on the same system, a feat useful for upgrading to a new version of Windows or for maintaining Legacy files after an upgrade to a newer OS version.

Connectix released its last version of Virtual PC (v.6.0) in December 2002. Two months later, Microsoft purchased Connectix's Virtual PC software and technology. Many of Connectix programmers then worked for Microsoft to continue Virtual PC development, soon releasing Virtual PC 6.1, the first Microsoft-branded release of Virtual PC. Virtual PC 7 will be released soon and will be the first major upgrade to the software since becoming a Microsoft product. ▲

PC 6.1 icon from the window to the Applications folder on our Mac's hard drive. Then, to configure the software, we double-clicked the Virtual PC 6.1 icon in the Applications folder, which launched the installation wizard.

This wizard guided us through the installation and configuration of Virtual PC. First, the wizard prompted us to choose a setup method. We clicked the Install From The Virtual PC CD Or An OS Pack radio button and clicked the Next arrow. Next, we used a slider bar to choose the amount of memory we wanted to dedicate to Virtual PC. Regardless of the amount of memory physically installed in the computer, the options range from 32MB to 512MB. We chose 384MB, which was more than the 256MB minimum required to run Virtual PC with WinXP on Mac OS X.

After selecting the memory allocation for WinXP, the wizard asked if we would like to enable Undo Drives. This feature works much like WinXP's System Restore. Undo Drives creates an image of your Virtual PC file. You can revert to this copy later if necessary. We clicked the Yes radio button.

Next, the wizard provided a field in which we could type a name for our virtual PC. We simply called our drive "Windows XP Home," which was the default name. If you want to change the location of the virtual PC file, you can also click the Change Location button and choose a new space on the hard drive. However, we left the virtual PC file in its default location in the Documents folder.

Parts List

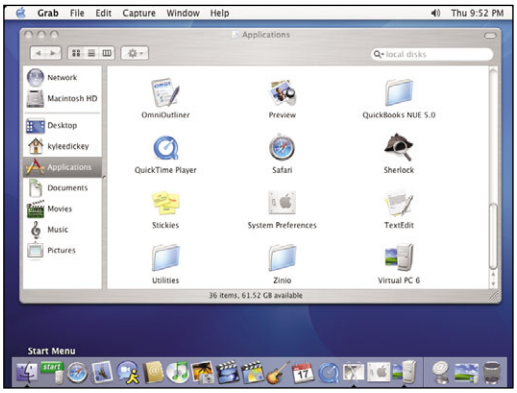
Part	Model	Price	Notes
System	Apple 1.25GHz PowerMac G4 with 1MB L3 Cache	$1,299	
Power Supply		$0	Came with system.
Motherboard		$0	Came with system.
Processor	1.25GHz PowerPC G4	$0	Came with system.
Memory	256MB PC2700 DDR 333 SDRAM (standard), plus 1GB DDR333 SDRAM (optional) —2 DIMMs	$225	$0 for 256MB, $225 for additional 1GB of RAM
Video Card	ATI Radeon 9000 Pro with 64MB DDR SDRAM and full dual-display support	$0	Came with system.
Sound Card	N/A		Came with system.
Connectivity	10/100/1000BASE-T Ethernet, AirPort-ready, v.92 56K modem	$0	Came with system.
Hard Drive	80GB Ultra ATA/100 7,200rpm	$0	Came with system.
CD/DVD Drive(s)	Combo Drive (DVD: 12X; CD: 32X/10X/32X)	$0	Came with system.
Monitor	N/A		Used an LG Electronics monitor we already had on hand.
Keyboard		$0	Came with system.
Mouse		$0	Came with system.
Microsoft Virtual PC For MAC 6.1 With Windows XP Home - Retail (S65-00002)		$195	
Symantec Norton Antivirus 2004 Professional - Retail		$49.99	
Symantec Norton Antivirus For MAC 9.0 With 1 Year Of Live Updates - Retail (10067159)		$65	
Total		**$1,833.99**	

Our system will store both Windows and Mac files. If we need to add more storage space in the future, we can easily slide out one of the three spare drive bays and add additional drives.

Finally, we had a chance to change any of the settings we'd chosen or any of Virtual PC's default settings. These choices included not only options such as memory allocation but also the file format (FAT32 or NTFS) for the virtual PC, the Undo Drives status, networking options, and USB support. For networking options, we chose to let Windows share a network connection with the Mac. This meant that we didn't need to reconfigure the network settings for Windows. We left the file format at the default FAT32. Mac OS X and Virtual PC support both, but there is better support for FAT32 than for NTFS at this time.

Once the program was installed, the Virtual PC List window appeared, and we clicked the Start Up button. At this point, the Windows installation began. The PC emulator was already installed, so the Windows setup screens that followed were the standard screens you would see when installing WinXP on a PC. If you've installed Windows on a PC before, the WinXP setup should be very familiar. When prompted for the Windows serial number, we used the serial number on the sticker attached to Virtual PC's installation-disc sleeve.

Protect OS X and Windows. After installing Virtual PC and Windows, we installed Norton Antivirus 9 for Mac and Norton Antivirus 2004 for Windows. You don't have to use Symantec's software, but you should install Windows antivirus software, as well as Mac antivirus software. If you don't install antivirus software for both Windows and Mac, your system will be vulnerable. The Windows software cannot protect your Mac files, and the Mac software cannot protect any files you run under the Windows emulation. It is generally best if you also use the same company's software for both OSes. For instance, if you choose to install a McAfee program for Windows, you should install McAfee's Mac software rather than one of Symantec's programs.



Virtual PC adds a Windows Start menu to the Mac OS X Dock for easy access not only to Virtual PC but also to other Windows applications, files, and settings.

Testing

Virtual PC is a very slick emulation. It is better integrated with the Mac OS than we would have expected, yet it still retains the basic feel of running Windows on a PC. The obvious exception to this is that Virtual PC tends to run much slower than an equivalent PC. However, most programs are more than usable. We wouldn't suggest using Virtual PC to run any Windows-based games, but for basic computing, Virtual PC gets the job done.

As we mentioned, we were very impressed with how well-integrated the Windows and Mac sides of our system were. For instance, Virtual PC could share the Mac network connection with Windows, eliminating the need for confusing configurations or emulating a number of x86-based network drivers.

Also, even a Mac user unfamiliar with Windows will be able to use Virtual PC without too much trouble. The software automatically adds a Windows Start menu to the Dock (a list of user-configured and currently open programs that appears at the bottom of the screen in OS X). From here, you can launch Windows applications, run Windows Update, and even change your Windows settings in its Control Panel. When you have Windows applications running, the Dock will also show an icon for each of these programs. You can click the icon to switch from the OS X application that is running to the Windows program's window. If you're a Mac purist and don't like your Dock littered with the Start button and Windows icons, you can access the Dock Settings and deselect Show Windows-based Applications In Dock and Show Start Menu In Dock.

It was simple to install new software on the system. Once you've started Virtual PC, insert an installation disc in your hard drive. While in the Virtual PC Windows environment, install the software according to the instructions in the software's users manual or an on-screen installation wizard. After you've installed the software, either right-click the CD on the toolbar or click the Drives menu and click Eject Disc.

You can run more than one version of Windows simultaneously if you have other versions of Windows on disc. For example, you might run Mac OS X, WinXP, and Windows 98 all simultaneously. This is a nice feature, as long as you are prepared for the system slowdown associated with running even more emulated programs.

You can make a backup copy of your Windows drive, applications, and files by exiting all Windows programs, shutting down Windows, and exiting Virtual PC (by choosing Turn Off PC from the Virtual PC's Shut Down options). Next, browse to your home directory in OS X and then double-click the Documents folder and make a back up copy of the Virtual PC List folder. If you ever want to restore this folder later, you can simply copy it over the version you want to replace. This will restore your virtual PC to its earlier state. We couldn't help but wish that it were always this easy to create a backup of a Windows PC.

If you don't want to back up the entire virtual PC but only copy individual Windows files, you can do this, too. Once again, you should exit all Windows applications, shut down Windows, and turn off your virtual PC. Then launch Virtual PC (if it isn't already running). In the Virtual PC List window, click the Settings button. Choose Drive 1 and click Mount Drive Now. This will mount a drive image of your virtual PC on the Mac desktop. You can then double-click the drive icon and copy individual files and folders for backup.

The above process of copying files from the virtual PC to the Mac was very easy once we read the Virtual PC users manual, but it was less than intuitive for those of us who sometimes gloss over software documentation. This was our only real complaint about Virtual PC 6.1, but it was hard to gripe too much about the need to launch a disk image of the Windows files when, after reading the documentation, the process worked as well as it did.

System Notes	
Physical Description	
Height	17 inches
Width	8.9 inches
Depth	18.4 inches
Weight	42 lbs
Other Physical Details: Side panel of case is hinged and folds down for easy access to the motherboard and drives for system upgrades.	
Feature Set	
Outstanding Features: 1MB L3 cache, supports up to 2GB of DDR SDRAM, DVI port, dual-monitor support, Gigabit Ethernet, four hard drive bays, DVD-ROM/CD-RW drive and additional optical drive bay, FireWire and USB ports, Mac OS X 10.3 Panther OS, and Microsoft Windows XP. Virtual PC is easy to use and lets you run Windows and Mac applications simultaneously.	
Weak Links: Virtual PC 6.1 emulates a Pentium II processor, so there is a limit to how fast Windows programs will run on this system. This computer is mainly for practical applications rather than gaming.	
Performance	
3DMark03: N/A - 3DMark03 couldn't run any of the four tests due to Virtual PC's graphics emulation.	
PCMark04: N/A - PCMark04 couldn't run enough of the tests to generate a PCMark System score. This was because Virtual PC 6.1 can't emulate 3D graphics and only emulates a Pentium II CPU.	

Final Remarks

We would have liked to build a true Frankenstein system that was a hardware-based half Mac/half PC machine. However, the incompatibility of the x86 and PowerPC architectures stood in our way. With an emulator as fine-tuned as Virtual PC, though, it really is possible to run both Windows and the Mac OS on a single system. The integration of the two OSes through Virtual PC was impressive, and we look forward to seeing what improvements Microsoft will make with Virtual PC 7. RS

by Kylee Dickey

Deliver Hot Tunes With A Cool Music Server

Build A Cheap PC & Pump Tunes To Your Home Stereo

Build #43 Skill Level: 1 2 **3** 4 5 ***Journeyman***

Welcome to the age of high-quality, high-fidelity MP3s. The advent of these near-CD quality digital tracks means you can access your music collection in ways you never dreamed of back in the dark days of 8-tracks and cassette tapes. You can store hundreds or even thousands of songs on a portable music player, and you can play libraries of MP3s on a compatible car stereo, all without changing the disc one time.

Goal

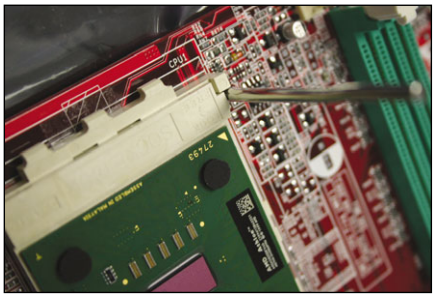
With your PC, you can store and play your MP3 tunes through a stereo that comes complete with a 7.1-channel sound system. But unfortunately, you can't play MP3s through your high-tech, beloved (and already paid-for) home stereo.

Or can you? Actually, you can play your tunes through your home stereo, provided you have the right equipment. We set out to build a low-cost PC that would combine with our existing stereo system to create a music station that would fill our home with sweet strains of Slayer on command.

We found that although music server technology is still very much in its infancy, there are plenty of options available to digital music aficionados. However, as you'll soon see, making some of these newfangled gadgets work might take persistence.

Background

We wanted to keep our music-server PC lean and extremely cost effective but mean enough to prevent its primary components from being technologically obsolete three months after we put the system together. That meant skimping on some of the extras and spending every dime where it counted, and though we didn't have any specific budget restrictions for this story, we hoped to keep our final price tag for our system at around $1,000.



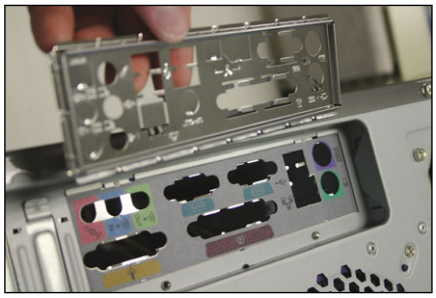
Installing the CPU is a snap. Just drop it into the socket and close the ZIF lever.

We started with the CPU, opting for an AMD Athlon 2800+ CPU with a 333MHz frontside bus and 512KB cache. This CPU by no means has the cutting-edge speed that gamers crave, but it's faster than average and should have enough oomph to make our music server go and then some.

Not wanting to deal with the headaches that result from cheapo motherboards, we stuck with a reasonably priced mobo from a trusted brand. With a price well under $100, our MSI KT

Parts List

Component	Price
AMD Athlon XP 2800+, 333MHz FSB, 512K Cache	$121
MSI KT600 motherboard	$63
Chaintech NVIDIA GeForce FX5200 Video Card, 256MB DDR	$84
Prismiq Media Player	$200
Prismiq Wireless Keyboard	$50
D-Link AirPlus PC Card Type-II 11Mbps Wireless DWL-650	$33
15-inch Off-lease Monitor	$30
Buffalo Technology 184-Pin 512MB DDR PC-2700	$84
Western Digital 200GB SATA Hard Drive, Model WD2000JD	$136
Logitech BLACK Optical Desktop PS/2 104 Keys	$20
Samsung 8X Internal DVD±RW Drive	$84
Antec Solution Series Super Mid Tower Case with 350W Power Supply	$64
Windows XP Home Edition	$72
Total	**$1,041**



We had to swap out the case's motherboard panel and replace it with the one that came in the mobo's box.

6V-LSR motherboard fit the bill, as it's equipped to handle up to 2GB of RAM and comes with plenty of onboard goodies, such as a 5.1-channel audio codec, Ethernet, and 8X AGP slot, which will help with upgrading when the time is right. This motherboard also supports SATA hard drives, a big plus that we planned to take advantage of.

We didn't want to overload on an expensive video card, as our 27-inch TV was designated as a primary output device. That's why we chose a Chaintech NVIDIA GeForce FX5200, which costs well under $100 but still comes with 256MB worth of video-processing punch.

We considered beefing up our system to include 1GB of RAM but decided not to due to budgetary concerns. We doubted our music server PC would really need more than 512MB, and if this limitation caused us problems, there was always the option of upgrading as needed.

System Notes	
Height	18.3 inches
Width	8.25 inches
Depth	18.6 inches
Weight	31 lbs
Features	
200GB, 7,200rpm hard drive	
512MB RAM	
Supports up to 2GB RAM	
5 PCI Slots	
AGP 8X	
5.1-channel Audio Codec	
4 USB 2.0 Ports	
Wireless Keyboard for MediaPlayer	
Benchmarks	
PCMark04	3223
3DMark04	1341

One area we didn't want to skimp on was storage. We wanted a speedy, high-capacity hard drive capable of storing huge numbers of photos, video files, and of course, audio clips. It would've been easy to find a 120GB, 140GB, or even a 160GB internal drive for $100 or less. Problem is, audio and video files eat drive space far too fast, especially for users who shoot their own video clips. That's why we chose a 200GB, 7,200rpm Western Digital SATA drive that we hoped would make a nice, spacious home for our beloved multimedia files.

We also wanted an optical drive that would handle all the needs of a serious multimedia machine. A regular CD-RW probably wouldn't be sufficient because we obviously needed something with at least basic DVD playback capabilities. And after considering that we'd need to back up at least some of our more crucial audio and video files, we didn't relish the idea of using CDs with 700MB capacities. That's why we ended up buying a DVD-RW drive that would let us archive data to 4GB discs.

The real necessity. The heart and soul of our music server system came in the form of the Prismiq MediaPlayer. This device devoured about 20% of the estimated budget for our music-server system, but its capabilities made it well worth the price. The MediaPlayer is a multitalented extension to a wireless home network that lets users play video files, view photos, and browse the Web, all on a TV. More importantly, though, this Prismiq product lets you access streaming Internet radio, or the MP3 library on your PC, and pipe these melodies through your home stereo.

The MediaPlayer is designed to be convenient. That's why it includes a remote control to let you sift through commands and why the company lists a wireless keyboard as an alternative input device. We spent the $50 for the keyboard, and we also devoted part of our budget to a wireless card so that we didn't have to run any Ethernet cable through the house; however, the MediaPlayer is designed to accommodate traditional CAT-5 cable if you'd like to use that option.

The Build

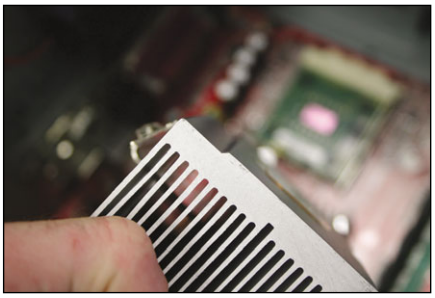
The build process for our PC went off well, but with a few minor surprises that you'll want to be wary of if you try the same setup. We'll get to those points later, but for now, we'll walk you through the steps we took to get the system up and running.

We started by clearing off a suitable work area and arming ourselves with a Phillips screwdriver. Then we opened the case and cracked our motherboard and CPU boxes, carefully laying the motherboard on our table with its antistatic bag underneath. After lifting the CPU socket lever, we aligned the CPU so that the golden arrow pointed toward the lever, dropped the chip into the socket, and locked the CPU in place.

We lowered the motherboard into the case and discovered that the mobo's ports didn't align with the openings on the back of the case. To address this problem, we retrieved the correct panel from the motherboard's box, unscrewed the panel from the case, and popped in the new one. This time the ports fit properly, so we pinpointed the holes on the case for our motherboard standoffs, which we then screwed into place.

With the motherboard resting on the standoffs, we inserted screws to keep the motherboard secure. A few of the standoff holes weren't perfectly aligned; however, after using a little force to insert two screws, subsequent screws went in with no strain.

Next, we inserted our RAM module into the slot closest to the CPU socket, taking extra care to make sure the module was oriented properly and the locking levers were tight. The CPU heatsink was next, and as with many AMD heatsinks, you need to make sure the ridge on one side of the heatsink goes over the bulky side of the socket, otherwise the heatsink won't be centered. The heatsink fan connected to a three-prong connector next to the RAM.

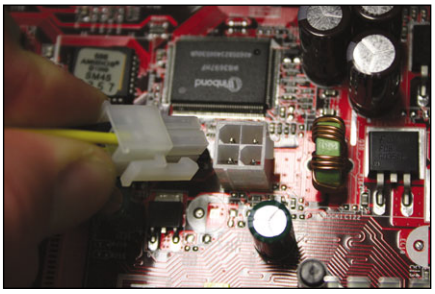


When you attach an AMD heatsink, always be sure that this ridge hangs over the bulky plastic on the socket.

Then we installed our floppy drive, hard drive, and optical drives. The case's enclosure for the hard drive and floppy drive slid out for easier handling, and we secured both drives to this enclosure with screws and then locked it into the case again. Our optical drive went into the top 5.25-inch drive bay.

Then it was time to do a little wiring. For the optical drive, we connected one end of our IDE cable to the drive and the other to the IDE #1 connector on the motherboard and then plugged a power cable into the drive. The floppy drive cable had a gap and a twist on one end, and this end went to the drive while the other end connected to the FDD connector on the motherboard. We grabbed the smaller floppy drive cable from the PSU and inserted it into the drive.

For our Serial ATA hard drive, we connected the narrow SATA data cable to the back of the drive and the other end to the motherboard connector called SATA #1. Our OEM hard drive didn't come with a SATA power cable, but our motherboard did, so we connected it to the drive and then to a regular PSU plug.



It's common for users to forget that this motherboard requires power from two cables. Don't leave out the second, smaller power plug, or you'll be wondering why your system won't boot.

We connected the primary power cables to the motherboard; as with Pentium 4 motherboards, this particular AMD CPU and motherboard require two power plugs to work correctly. These connectors are keyed and impossible to plug in backward. If you need help finding any motherboard connectors, just check the motherboard's booklet.

Using the diagrams in the clear and concise MSI manual, we connected the Power and Reset switch plugs to the correct motherboard pins. It doesn't matter how you orient these plugs, as all you need to do is complete the circuit to make these buttons work.

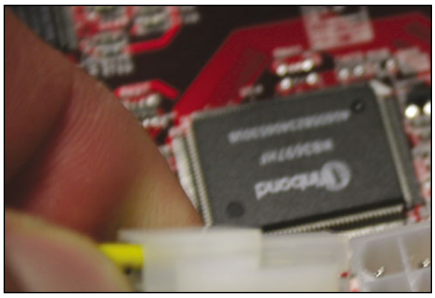
To make room for our video card, we slipped out the AGP slot cover on the back of the case. Then we screwed the card into place.

Testing

We pressed the Power button and the system sprang to life. With the Windows XP CD in our optical drive, we pressed F2 to continue the startup process. When a blue screen appeared with a message about loading third-party RAID or SCSI drivers, we pressed F6, not because we were planning to install either of these devices but because WinXP needed a driver to communicate with our SATA hard drive.

We inserted the floppy driver disk provided by MSI and pressed the *S* key to specify that the driver was in drive A: and then chose the VIA Windows XP Serial ATA Controller menu option. After we pressed ENTER, our PC stopped responding. To make things work properly, we needed to alter our computer's boot sequence. We restarted the computer and pressed the DELETE key to enter the BIOS menu. Using the Advanced BIOS Setup option, we found the Boot Sequence setting and changed this setting so that the computer started booting with the floppy drive, then the CD/DVD drive, and finally the hard drive.

To make sure our computer was running at full speed, we checked the frequency and voltage control settings and increased the CPU FSB Clock from 100MHz to 166MHz. Then we saved our changes and exited the BIOS menu.



You can orient the power switch plug either way. Just be sure to use the motherboard diagram and match the plug to the right connectors.

The computer again began loading WinXP setup files, and this time, we didn't run into any problems. When we were prompted to partition the drive, we simply pressed ENTER to create a single partition on the entire 200GB drive. WinXP prompted us to select a method for formatting the hard drive, and we chose the NTFS Quick option. WinXP formatted the drive in just a few moments and then began copying OS files to the hard drive.

Installing WinXP was straightforward and a matter of clicking through basic on-screen options. At the end of our WinXP installation, we were prompted to activate our copy of the OS. When we attempted to do so, however, lo and behold, we received an error message that indicated our product key had already been activated. We did some digging and found out our super-cheap WinXP deal was really a scam, so we alerted Microsoft and called

Time-saver

If you let the MediaManager scan your hard drive for media files, and you have thousands of files for the program to sift through, start the scan when you're asleep or away. This process takes a long time and slows down your computer in the meantime. In addition, if you have a relatively slow processor, the program can slow your computer to the point that you experience errors when you play back files using MediaPlayer. ▲

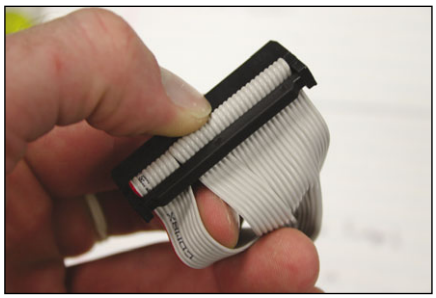
Watch Out

The Prismiq MediaPlayer works with only certain wireless card models and, sometimes, only certain revisions of specific models. Contact the company for a list of compatible cards before you buy, or check out the compatible-cards list on the Web site. The company continually updates this list to stay current with the many changes that happen in the wireless card market. ▲

our credit card company to get our money back.

With our legal copy of WinXP in place, we checked the Device Manager and found two yellow exclamation points, one on our video card and the other on a multimedia device. We used our Chaintech driver CD to install the video driver, and our MSI driver CD contained a driver that resolved our multimedia driver problem. From there, we used the Windows Update site to install many megabytes of necessary software updates.

Player setup. The MediaPlayer's configuration was the key to completing our music server system. As soon as we opened the box, we had a feeling things wouldn't go quite as smoothly was we'd first hoped. In the product's release notes, we found a section called Wireless Card Support, which lists 28 supported cards, and only two (from NetGear and SMC) were highlighted as "recommended." Bemused, we did a few quick searches and found numerous forum-based complaints about wireless card setup problems and many more messages that referred to general configuration difficulties.



Make sure you connect the twisted and split end of your floppy connector to the drive.

Nothing in the retail site product description mentioned that users should buy a specific card. We were fortunate, having picked a super-popular D-Link card (the DWL-650) that we hoped would work with a number of products, and this card happened to be on Prismiq's list.

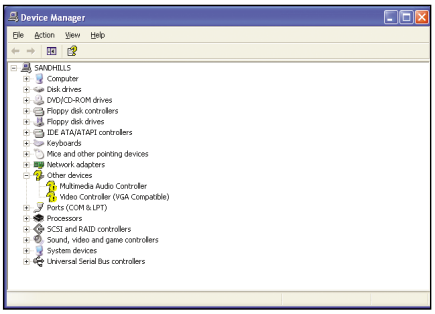
To complete our setup, we connected the MediaPlayer to the back of our Sony television with the included S-video cable. Then we connected the left and right audio cables to the AUX connectors on the back of our Sony receiver.

We installed the MediaManager software on our PC. During this process, the program prompted us to scan the hard drive for audio, video, and image files, in essence creating a quick-access catalog of available multimedia files.

Before we continued tinkering with the MediaPlayer, we decided to take a break while our computer got its feet wet with two benchmarking applications. We started by running the system suite and CPU tests in PCMark04. After the dust settled, we saw a solid score of 3223. Then we ran the tests in 3DMark03. Our final score was 1341.

Then it was time to try out our MediaPlayer. We double-checked to make sure all of our products were connected and then restarted the computer. The MediaPlayer startup screen appeared on our television but then indicated that it could not find a computer with media files on it. When we started MediaManager on our PC, the program informed us that we needed to update our version of the application. This required us to download and install nearly 40MB worth of files, a process that took more than 10 minutes, after which we had to rerun the configuration program.

We restarted our setup but the MediaPlayer still didn't find our network. We tried resetting our router numerous times to simplify things, to no avail. Then we called Prismiq tech support for help and found out that the player does accept the D-Link DWL-650, but not the specific revision of the card that we purchased. The company representative explained that card manufacturers often tweak their products without notifying other



Our graphics card and motherboard driver discs helped us make these unrecognized devices work properly.

hardware makers, and because of this, sometimes certain cards that should be supported don't work quite right—or in our case, not at all. Though the company does regularly update its list of compatible cards, you'll have to call to verify the compatibility of any card you want to buy.

We contemplated buying another wireless card, but deadlines forced us to go another route. After we perused more forums about MediaPlayer problems, we were glad we opted to ditch the card concept. Other users complained about blips in their wireless networks (caused by other electronic devices and physical interference) that caused rough audio and video playback.

To work around the wireless card problem, we removed the card and used an Ethernet cable instead. Finally, the player found our network but informed us that it needed to upgrade its software. This took five minutes. Then the player indicated it needed to upgrade its firmware, which took a few minutes more. After all of this, we managed to find and play music files from our PC to our home stereo.

Final Remarks

Our music server machine did its job effectively, though only after a few hours of tweaking and frustration. You should expect similar problems if you buy a convergence device of any kind for your home. The technology is intriguing but, as of yet, imperfect, especially for users who need plug-and-play functionality for every networked device they use. RS

by Nathan Chandler

Best Flat-Screen, HD-Capable Home Theater System Under $3,000

Redefine Your Entertainment Center

Build #44 Skill Level: 1 2 3 4 5 *Master*

Parts List		
Item		Price
Case	SilverStone Black Lascala Desktop SST-LC01 Case	$105
TV Monitor	Sharp AQUOS LC-22SV6U 22-inch LCD TV	$1,217
PC Monitor	IBM G78 1,280 x 1,024 17-inch Flat-Black Monitor (Recertified)	$90
PSU	Enermax EG365P-VE 350-watt ATX	$50
PSU #2	Allied 400W Power Supply, Model # AL-A400ATX	$35
Mouse	Optical Scroll Mouse	$5
Keyboard	Keyboard SK-700B	$4
Mainboard	SOYO SY-P4VTP Socket 478	$54
CPU	Intel Celeron 2.4GHz	$68
RAM	Kingston 512MB DDR PC-3200	$181
Hard Drive	Maxtor DiamondMax Plus 8 40GB 7,200rpm ATA/133 EIDE HD	$49
Optical #1	ASUS Black 16X DVD-ROM	$31
Video Card	PowerColor Radeon 9700 Pro Video Card	$195
Sound Card	M-AUDIO 7.1-Channel PCI Sound Card, Model Revolution 7.1	$89
OS	Windows XP Home Edition (OEM Full Install)	$64
Speakers	Creative GigaWorks S750	$415
Misc.	WinTV-HD PC-Based High-Definition TV Receiver	$292
TOTAL		**$2,944**

One result of the ongoing convergence of computers and entertainment centers is the HTPC, or Home Theater PC. Microsoft's Windows XP Media Center Edition and MCE-equipped PCs may be the most hassle-free way to get an HTPC, but *PC Builder* isn't about doing things the easy way. And, of course, the easiest way isn't always the best way; in this article, we'll show you the best way to build an HTPC for less than $3,000.

Goal

Our goal for this system was to create a fully HD-ready HTPC. We wanted a system that was sleek, silent, and serious about home theater. Upon completion of this build, all you'll have to do is feed this monster a DTV signal, and then you can sit back, relax, and bury yourself up to your eyeballs in digital content.

Background

An exceptionally powerful CPU is wasted on a home theater system designed specifically for HDTV. Digital television relies on bandwidth more than computing power, which is why we chose an Intel 2.4GHz Celeron over more cutting-edge options. The motherboard we decided on was the SOYO SY-P4VTP, which is a Socket 478 board based on the VIA PT800 chipset. We chose the SY-P4VTP because it is cheap, supports DDR 400 memory, has an 8X AGP slot, and has a slightly reduced form factor. We chose a 1GB dual kit of Kingston DDR 400 memory, though half that much is more than enough.

We bought an ATI Radeon 9700 Pro video card, which should be more than sufficient for displaying games and flawless DVD video. The Radeon 9700 Pro features an S-Video output, which we used for

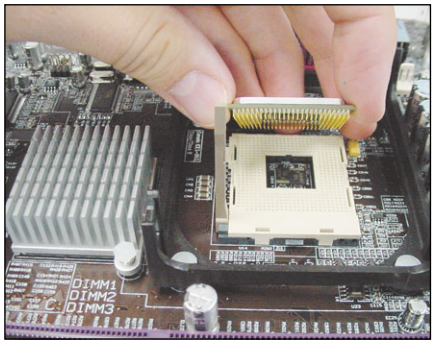
Sometimes Intel just doesn't get its way.

System Notes	
Outstanding Features	The 7.1 GigaWorks speaker system was easy to set up and sounded great. The Sharp AQUOS LCD TV is, well, sharp.
Weak Links	The Maxtor hard drive was a little too noisy for our taste.

connecting to our LCD TV. We opted for M-Audio's Revolution 7.1, a standalone sound card that gave us more channel support than we knew what to do with. The key item that makes this an HD-ready system is Hauppauge's WinTV-HD PC-based HDTV receiver. The HD tuner was the most expensive internal component for our system; only the Creative GigaWorks speaker system and LCD TV took a bigger bite out of our budget.

The hard drive we chose needed only to be large enough for our OS and several apps. A single 40GB Maxtor DiamondMax hard drive was enough to store the OS, a few games and a slew of compressed audio files. The optical drive we priced for this system is an inexpensive ASUS 16X DVD-ROM drive, but we used a similar DVD drive that we had on hand.

As mentioned earlier, the spending limit we targeted for this system was $3,000. That's a sizeable amount, but one that is still realistic for many household budgets. We certainly would have enjoyed having a budget of $5,000 or so to start off with, but then again, many times system builders have to compromise and let go of the dream hardware in favor of more affordable components. Although Sharp's 37-inch widescreen AQUOS LCD with an HDTV-compatible resolution of 1,366 x 768 seemed like the perfect flat-screen TV to complement our system, the 22-inch AQUOS we ended up with still got us plenty of compliments, and it's almost exactly two grand cheaper. We also picked up a recertified IBM G78 CRT monitor to help us tweak the display settings.



The CPU pins line up with the holes in the socket.

Our case had to be a desktop attractive enough to blend in with the audio and video equipment found in an average home theater enthusiast's entertainment center. Desktop cases are well-known for running hot, so we chose the smart-looking black SilverStone Lascala case, which has a rear exhaust fan to help keep temperatures down. The case's front bezel features two fold-down panels for access to the drives, a power button, and two blue LEDs. We had a used 350W Enermax power supply in-house, so we borrowed it for this project.

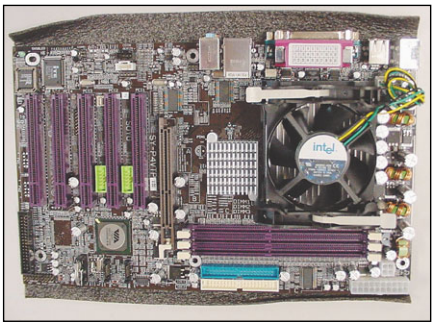
We picked up a generic PS/2 keyboard and optical mouse for less than $10, got a copy of Windows XP Home Edition, and we were ready to dive in.

The Build

We found a clean flat work surface upon which to build our system and made sure to touch a grounded piece of metal to dissipate static electricity. We then set out the components we wanted to assemble first, including the motherboard, processor, heatsink, RAM, and case. Next we familiarized ourselves with the SY-P4VTP motherboard and glanced at its users manual for tutorials, specific warnings, and layout diagrams. After taking stock of the various included parts, connectors, and accessories, we looked to the processor.

CPU, heatsink, and RAM. Our 2.4GHz Celeron came with a stock aluminum heatsink. There were no written installation directions, just a series of eight illustrations complete with arrows indicating various motions and a warning on the box that read, "This product is intended to be professionally installed." We opened the box and set out the CPU and heatsink. Following the illustrations, we lifted the ZIF lever, made sure the processor pins lined up with the pins on the socket, and positioned the CPU on the motherboard. We then lowered the ZIF lever to secure the CPU to the socket and turned our attention to the heatsink.

The Celeron's heatsink employs a thermal pad, which looks like a black square of foil. We made sure the thermal pad was intact and set the heatsink over the CPU. With the two gray locking levers open, we snapped the heatsink's plastic frame to the mounting frame of the motherboard. With a little effort, we locked the levers down flush with the frame. The CPU fan plug went to the header labeled CPUFAN1 and the chassis fan to the CHAFAN1 header, which we found between the PCI slots.


Our narrow ATX form factor motherboard sports its new CPU and heatsink.

The RAM modules went into DIMM slots 1 and 2, as designated by the manual. Again, we made sure we were grounded and then positioned the first stick of PC3200 RAM in the slot closest to the heatsink. The memory module was notched so that it only fit into the slot one way. With the ejector tabs open, we pushed the module into place, one edge at a time, until the tabs locked the module down. We followed the same procedure for the second module, using the next slot labeled DIMM 2.

PSU and motherboard. Before installing the motherboard, we needed to prep the case. We removed the four black anodized screws and slid the cover back while lifting up to expose the inside of the case. Our Enermax PSU secured to the case with four screws. We removed the input/output plate that came with the case and replaced it with the one tailored to our motherboard.

The SY-P4VTP's reduced size meant using fewer standoffs to secure the board to our case. With the motherboard inside the case, we were able to install the right side standoffs by sliding the board to the left and then moving the motherboard back to the right to install the remaining standoffs. When all six corners were secured with the provided screws, we supplied power to the motherboard with both the 4-pin auxiliary

connector and 20-pin ATX power connector. The PSU's auxiliary fan plugged into the CHAFAN2 header near the heatsink.

Our next task was to connect the system panel connector, which consists of the case's power switch, hard drive LED, and power LED. The POWER SW plug from our case corresponded to the PWRBT header on the motherboard. Most system panel headers and case plugs are labeled so that their associations are obvious. Next, we went about plugging in the front panel USB and audio ports. The USB header diagram that came with the motherboard was extremely difficult to decipher, so we used an illustration we found at SOYO's Web site (www.soyousa.com/kb/kbdesc.php?id=112). The manual's audio header diagram was equally useless, but once we figured out that the MIC POWER plug corresponded to the VCC pin, everything else fell into place.

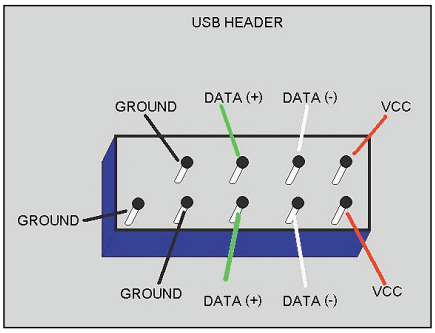
Drives. The system's optical and hard drives went in next. We started by removing the side of the drive cage and installing the drives with four screws each. We used the middle 3.5-inch slot for our hard drive and placed our DVD drive in the only open slot at the top of the cage. We had to remove the metal drive cover from the 5.25-inch slot to give us access to the bay.

When we first opened the box for the SY-P4VTP, we found it sorely lacking in extras. For a $50 motherboard we weren't expecting extra FireWire and USB brackets, but we would have at least liked more than one IDE cable. As a result we decided to try putting our DVD drive and hard drive on the same channel, even though we had a second IDE port on the board and extra cables lying around. Keeping both drives on the same channel reduced the throughput of our faster drive to the top speed of the slower drive, but given the fairly limited use of this PC, we figured that would be OK.

We set the DVD drive's jumper to the slave position and the hard drive's jumper to the master position. If you're following along, keep an extra IDE cable handy, because you'll need it. Also, check out the "Watch Out" sidebar in this article for more information on jumper settings.

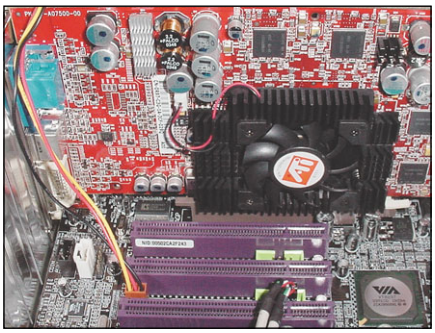
The drive cage was easy enough to remove, but reinserting it so that the optical drive's faceplate breached the front panel of the case took a little effort. We secured the cage with two screws and connected the power to the drives with Molex plugs from the PSU. The blue plug of the IDE ribbon cable connected to the IDE1 port on the motherboard. Each 40-pin plug on the ribbon cable had a notch so it would only fit into the motherboard and drives one way.

The used 350W Enermax PSU might have been the reason our system unexpectedly shut off.



This diagram describes the pin configurations for the internal USB plugs.

The jumper on our optical drive designates it as the slave device for our primary IDE channel.



Our ATI Radeon 9700 Pro takes its place in the mobo's AGP slot.

Video card and peripherals. Next we installed the Radeon 9700 Pro. We opened the lock on the AGP slot and removed the corresponding bracket to make room for the input/output ports of our video card. We then slid the video card in place until the AGP lock engaged. In the second PCI slot from the top (close to the AGP slot), we installed the WinTV-HD card, and finally we installed the M-Audio Revolution 7.1 sound card in the bottom PCI slot, securing each card by screwing the brackets to the case. We also connected a power plug from the PSU to the video card.

Last of all we connected the IBM G78 monitor, LCD TV, keyboard, and mouse and did one last check of all the ports, plugs, headers, leads, and power connectors. We made sure the PSU was switched on and the voltage switch was set to 110. A green LED lit on the motherboard to indicate that the board was getting power.

Testing

We turned the monitor on first and waited for it to warm up. The LCD TV remained off until we had the display properly configured. After pressing POWER on our case, we noted that all of the fans started spinning and the power LED on the front of the case lit up. The first screen that appeared was the Phoenix BIOS logo screen with the message CMOS Checksum Error- Defaults Loaded. We were given the option to press F1 to continue or DELETE to enter setup. We wanted to check our BIOS setup, so we pressed DELETE.

In the BIOS Configuration Utility, we set the correct date and time and checked to see if the system had detected our optical drive. Next, we put the WinXP CD into our DVD-ROM drive. Then we checked the Advanced BIOS Features menu and set the boot device priority so that the system tried the optical drive before the hard drive. We pressed F10 and ENTER at the Do

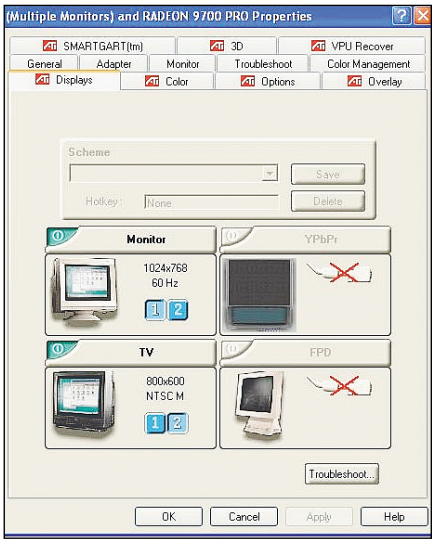
You Want To Exit And Save prompt, which rebooted the computer.

When the computer was on again, it prompted us to press any key to boot from ATAPI CD-ROM, so we pressed the Spacebar. Next, the blue Windows Setup screen appeared, and our system began to load files from the disc. We pressed ENTER when prompted to set up WinXP and then pressed F8 to agree to the terms of the WinXP license agreement. We installed the OS on the partitioned space and pressed ENTER. After selecting the option to Format The Partition Using The NTFS File System (Quick), we pressed ENTER again. The next screen informed us that formatting the drive deletes everything on it, so we pressed the *F* key to begin the format. Once the drive was formatted, the system copied files to the Windows installation folders, initialized, and then prompted us to reboot the computer, which we did by pressing ENTER.

As the system started, we immediately pressed DELETE to access the BIOS Configuration Utility. We selected the Advanced BIOS Features and changed the boot priority back to our hard drive and then we pressed F10 and ENTER to save the changes and reboot the system.

When the system restarted, we saw the WinXP Home Edition loading screen, followed by the language options screen and the name and company screen. After entering the license key, we were asked to name the computer, update the time and date information, and configure our network settings. We didn't immediately install the motherboard drivers for our system, but it may be a good idea to do so to ensure system stability. We proceeded to load the drivers for our video and sound cards after which we were told to reboot, so we did.

Our next task was to configure the LCD TV display for watching DVDs. We didn't have a DTV signal to wire to our rig, but the signal would come into the HD tuner card via a coaxial plug, which would then route to the LCD TV. With the LCD TV plugged into the S-Video port on the video card, we right-clicked the Desktop visible on our test monitor and clicked Properties to open the Display Properties dialog box. Next, we clicked the Settings tab and then



The Multiple Monitors dialog box shows us the different settings for each display.

the Advanced button, which opened the Radeon 9700 Pro Properties dialog box. Under the Displays tab we set the system up to use both the monitor (as primary display) and the TV (as secondary display). We set the monitor's display resolution to 1,024 x 768 and the LCD TV resolution to 800 x 600. With a shared Desktop, we were able to play a DVD on the LCD TV while surfing the 'Net on the test monitor.

Problems

While the DVD drive worked and appeared in our BIOS, it didn't appear in My Computer. A quick jaunt into the Add Hardware Wizard verified that the drive was functioning properly. We checked My Computer again and the drive appeared. After attempting to install the HDTV tuner card, we rebooted the PC only to find our optical drive missing from My Computer again. We shut the system down and opened the case. All the connections looked good. Our first attempt at a solution was to set the drive's jumper to cable select and remove the hard drive jumper completely. (There was no labeled cable select setting.) We restarted and still no dice, so we opened the case and put the hard drive on the IDE2 port and the DVD drive on the IDE1 port. When the PC was up and running again, the problem was fixed.

The next problem we ran into is still a bit of a mystery. While testing the sound system with the Activision first-person shooter Call Of Duty, the screen suddenly went black and the system shut off. Our first thought was that our processor might have overheated. We checked the temperatures in the BIOS Configuration Utility and made sure there that the emergency shutdown temperature wasn't set too low. All of our temperatures looked within acceptable parameters, so we started the system again and tried to duplicate the problem. This time, we played the same game for a full hour without incident. The one questionable component of our system was the used PSU, so we turned the system off and replaced it with a new 400W Allied PSU. The abrupt shutdown didn't happen again, so your guess is as good as ours.

Watch Out

When configuring multiple drives to a single channel, pay careful attention to the jumper settings. Most EIDE device cables can support multiple devices, with the one plug intended for your master device (first device detected by the system), and another plug intended for your slave device (second device detected by the system). If your motherboard allows, put the devices on separate channels; otherwise, rely on the master and slave jumper settings. In our experience, cable select rarely works properly. ▲

Final Remarks

If you're building an HTPC as your second system, there's no need to buy an extra monitor for testing display settings. With the extra money (assuming you've already chosen your LCD TV), you can splurge on a larger hard drive, which you can use to turn your system into a music server. You can also use the GigaWorks sound system to upmix your audio files to take advantage of those extra speakers. Combining a home theater setup with a PC is still a fairly underdeveloped concept, but hopefully we've helped you develop your own idea of the perfect HTPC. RS

by Andrew Leibman

5.1 Surround-Sound System For Under $1,250

Real-World Audio For A Real-World Budget

Build #45 Skill Level: 1 2 3 4 5 ***Novice***

Real life happens from all sides. Unfortunately, however, the vast majority of the audio media we're exposed to utilizes a mere two signals, a right channel and a left channel. A low-signal channel can help with the audio levels that we feel more than hear, but the addition of two surround-sound channels and a center channel for movie dialogue takes us out of the spectator's seat and places us squarely in the middle of the action. This most basic surround-sound configuration, commonly referred to as 5.1 (consisting of five standard speakers and a subwoofer), is light-years beyond stereo and brings us a step closer to experiencing real life from the comfort of our living rooms or office chairs.

Goal

The purpose of this system is to provide the most realistic listening environment for music, games, and movies. You can easily build a surround system that costs twice as much, or even half as much, both of which are able to play the same media with varying degrees of quality. We settled on a realistic budget of $1,250 but we got away with spending about $60 less than that.

Background

Although we wanted a powerful multi-use system, we didn't need a 939-pin or 3.8GHz CPU, so we chose AMD's Athlon XP 3000+, which features a 2.16GHz clock speed and 333MHz FSB. The Socket A motherboard we settled on was the feature-rich ASUS A7N8X-E Deluxe, which is built around the nForce2 Ultra 400 chipset. Our versatile board came with an integrated Dual LAN (10/100, and Gigabit) network adapter, a Silicon Image RAID controller for SATA hard drives, an 8X AGP slot for a powerful video card, and support for DDR 400 dual-channel memory. The A7N8X-E Deluxe also features an onboard six-channel APU (Audio Processing Unit), but we wanted the additional functionality of a standalone sound card.

We went with a 1GB dual kit of Kingston DDR 400 memory to take advantage of the dual-channel support of our motherboard. Dual-channel memory kits tend to cost a few dollars more than individual sticks (no bulk discounts with RAM), but the extra throughput is worth it.

We bought an ATI Radeon 9700 Pro video card, which should be more than sufficient for the latest games and flawless DVD playback. Our audio card is Creative's Audigy LS, which delivers six-channel surround sound and 24-bit Advanced HD audio. We chose to populate our listening area with MidiLand's stylish MX-5 5.1 speaker system.

We went with an 80GB Samsung SATA hard drive, which should give us plenty of space for games and uncompressed audio files. Despite the faster throughput, using a SATA drive necessitates a floppy drive in order to install the drivers during setup. Fortunately, floppy drives are cheap enough to keep them at reasonable expense. The optical drive we used is an ASUS 16X DVD-ROM drive. We would have spent twice as much to get a DVD-ROM/CD-RW drive and several times more for the ability to burn DVDs, so we kept it simple.

For a display we chose a flat-black, recertified IBM G78 CRT, and when it came time to select a case we picked the Sonata, a piano-black steel case from Antec. The Sonata is a "quiet case" that comes with a dual-fan 380W Antec TruePower PSU, as well as front-panel audio and USB and

System Notes

Outstanding Features: The 5.1 MX-5 speaker system looked very sleek along with our black monitor and black case. The 5.1 surround sound really brought us into the experience of our games and movies.

Weak Links: The speakers were merely adequate. If you've got the money, spend it on a higher-quality sound system.

FireWire ports with nifty blue LEDs. The Sonata also includes a massive 120mm fan.

Finally, we bought a no-brand PS/2 keyboard and optical scroll mouse for less than $10 and secured a copy of WinXP Home Edition for our 5.1 surround-sound system.

The Build

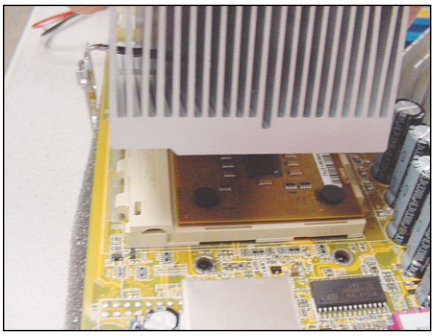
We started by removing the rear thumbscrews and unlatching the side panel from our Sonata case. We inspected the front panel and PSU connectors and then checked to make sure all the accessories and screws were included. At this point we removed the input/output plate that came with the case and replaced it with the one that came with the A7N8X-E Deluxe motherboard. Whenever handling sensitive components, we made sure to diffuse static electricity by first touching a grounded and unpainted piece of metal. We removed the motherboard from its antistatic bag and laid it on the included piece of foam. We proceeded to check the various accessories and inspect the manual. The motherboard also came with a Quick Setup Guide, which details the specifics of building a system using the A7N8X-E Deluxe. When we were familiar with the motherboard and the manual, we examined the CPU.

CPU, heatsink, and RAM. When mounting our hardware to the motherboard, we made sure we were working on a clean, flat surface. The AMD Athlon XP 3000+ processor included the stock aluminum heatsink (with a copper core) and illustrated step-by-step instructions. We followed the instructions and carefully set out the CPU and heatsink. Next we lifted the A7N8X's socket-locking arm to a 90-degree, or open, position. The pins on the processor correspond to the holes in the socket so that they only fit one way. We lined up the CPU and slid it into place with ease. Next we locked the socket arm down to secure the processor to the motherboard.

The heatsink connected to the motherboard with a V-shaped clamp. We started by removing the plastic cover that protects the thermal compound and positioning the heatsink so that the clamps lined up with the locking lugs of the socket. The bottom of the heatsink is notched so that it sits on the socket evenly. We latched the small clamp to the locking lugs by hand and then used a screwdriver to carefully maneuver the opposite side of the clamp over the three locking lugs of the socket. It's important to use extreme caution when using a screwdriver to mount the heatsink because one erratic stab can cost you a motherboard. Finally, we plugged the CPU fan plug into the header labeled CPU_FAN1.

The A7N8X's manual details memory configurations specific to the amount and type of system memory we planned to install. The manual suggested using the two blue slots for dual-channel memory, leaving the black slot vacant. Again, we made sure we were grounded, opened the ejector tabs, and positioned the first stick of PC3200 RAM in the blue slot labeled DIMM_A2. The memory module is keyed so that it only fits into the slot one way. We pushed the module into place, one edge at a time, until the tabs locked the module down. We followed the same procedure for the second module using the blue slot labeled DIMM_B1.

Motherboard and power supply. The standoffs are all that support the motherboard in the case, so applying pressure while plugging in cables may be enough to damage the board. For this reason we chose to connect the IDE and floppy drive cables prior to installing the board. We plugged the floppy cable into the port on the motherboard, making sure the white wire corresponded with pin No. 1 on the plug. If you're not sure which is pin No. 1, there is a pin missing on the port and one hole is missing on the plug; line them up and you'll be in good shape. (Note, however, that not all ports and plugs are configured like this.) The IDE cable for our DVD-ROM drive had a similar pin and hole configuration, so we plugged it into the port labeled PRI_IDE1.



The bottom of the heatsink is notched to fit the surface of the CPU and socket.

Next we set the motherboard into the case and noted where we'd have to install standoffs. We installed the standoffs in the appropriate holes and screwed the motherboard to the case. The motherboard barely fit between the rear exhaust fan and the drive bays of our Antec case, but we had very little difficulty getting it secured. We supplied power to the motherboard with the 20-pin ATX power connector and ignored the auxiliary 4-pin power plug used primarily for boards that support

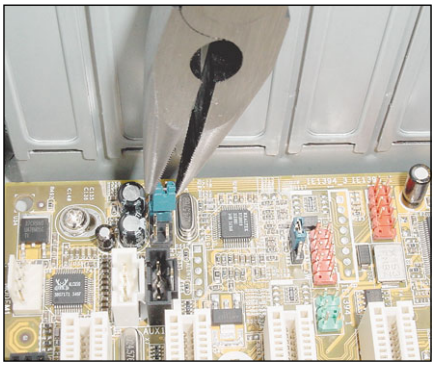
Parts List

Component	Model	Price
Case	ANTEC Life Style Black Case/380W Power Supply, Model SONATA	$99
Monitor	IBM G78 1,280 x 1,024 17-Inch Flat Black Monitor (Recertified)	$90
Mouse	Optical Scroll Mouse	$5
Keyboard	Keyboard SK-700B	$4
Mainboard	ASUS A7N8X-E Deluxe	$93
CPU	AMD Athlon XP 3000+	$146
RAM	Kingston ValueRAM Dual Channel Kit 1G (512MBx2) DDR PC-3200	$181
Hard Drive	Samsung 80GB SATA Hard Drive	$79
Optical #1	ASUS Black 16X DVD-ROM Drive	$31
Floppy Drive	Mitsumi 1.44MB 3.5-inch Floppy Disk Drive	$13
Video Card	PowerColor Radeon 9700 Pro Video Card	$195
Sound Card	Creative Labs Sound Blaster Audigy LS	$53
OS	Windows XP Home Full OEM Version	$64
Speakers	MidiLand MX-5 5.1 Speaker System	$83
Software	Doom 3	$50
Total		**$1,186**

Pentium 4 CPUs. Our next task was to connect the system panel connector, which consists of the case's power switch, reset switch, IDE and power LEDs, and internal speaker. We checked the motherboard manual's diagram and matched the leads with the labeled plugs, all the while keeping the plug labels facing outward.

The USB plug from the case was labeled, but the FireWire plug is blank. We connected the front-panel USB and FireWire cables to the USB56 and IE1394_1 headers, respectively. Our front-panel audio ports came with a single plug that conforms to Intel's audio connector standard. After removing the jumper caps, we connected the plug to the audio headers on the motherboard labeled FPAUDIO1. The rear exhaust fan used a standard Molex plug, so we connected it to the PSU with a plug labeled FAN ONLY. Finally, we connected the PSU fan plug to the header on the motherboard labeled PWR_FAN1 and the Molex front-panel LED plug to the PSU.

Pin No. 1 is on the left side of the port.



We had to remove the jumper caps in order to install the front-panel audio plug.

Drives and audio/video cards. The internal 3.5-inch drive bays of our Sonata case include trays that slide in and out with ease. By squeezing the release clips on either side, we were able to remove the bottom tray. We then used the proper screws to secure the hard drive to the tray through the bottom rubber grommets. Next we connected the power and the SATA cable. We positioned the drive in the tray so the SATA and power connector faced the rear of the case and then fed the SATA cable above and behind the drive to keep the excess wire out of the way. We connected the SATA cable to the SATA_RAID1 port on the motherboard.

Next we removed the top 5.25-inch drive bay cover and installed the purple rails on either side of the DVD-ROM drive. We slid the optical drive into the top bay until it clicked. We removed the 3.5-inch drive cage, secured our floppy drive with four screws, and snapped the cage back into our case. Next we connected the ribbon cables to both the floppy drive and the DVD-ROM drive. Then we connected the appropriate power plugs to the drives.

Our next task was to install the video card. We removed the corresponding rear panel bracket (second from the top) to make room for the input/output ports of our card, slid the 9700 Pro into place, and screwed the card's bracket to the case. In order to make room for the Sound Blaster Audigy LS sound card, we removed the bracket that corresponded to the middle PCI slot. We slid the card into the slot and bolted the bracket to the case. Then we supplied power to the 9700 Pro with a Molex plug from the PSU.

We then needed to create a driver disk to get our PC to recognize the hard drive. Using another system, we explored the CD-ROM that came with our A7N8X motherboard and inserted a blank floppy disk in the drive when we found the files we were looking for. We selected the nine files (not the GUI or Linux folders), right-clicked the selected files, and clicked Send To. We clicked 3.5-inch Floppy and waited for the files to copy to the blank disk.

Final checks and speaker placement. Back at our system in progress, we did one last check of all ports, wires, plugs, and connectors. We plugged the monitor, mouse, and keyboard into the computer, made sure the PSU voltage switch was set to 110, and then plugged the PSU power cord into a wall outlet. We configured our MidiLand MX-5 speakers in the optimal setup, with the front left and right speakers flanking either side of the monitor and the rear left and right speakers approximately 3 feet behind our sitting position. The four speakers formed a square with our chair in the middle. We aimed the speakers diagonally so the rear left and right speakers faced the front right and left speakers respectively. We placed the subwoofer approximately 8 inches from the computer tower and placed the center channel speaker on top of the monitor. Next we plugged the speakers and control switch to the subwoofer.

Testing

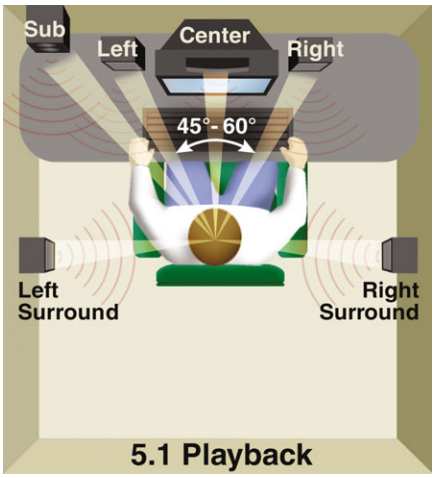
We began testing our surround-sound system by powering up the speakers with the volume dial on the control switch. Next we turned on the monitor to let it warm up. With the PSU switched on, we noticed that a green LED lit to notify us that the motherboard was getting power. We pressed the power button on the tower and watched as the fans started spinning. We watched the monitor and chose to wait before entering the CMOS Setup Utility. To our surprise the system booted to a screen that informed us that Windows had not started successfully, which gave us the option to start Normally, start in Safe Mode, or start with Last Known Good Configuration. Just to satiate our curiosity we tried each option. Alas, each time, after the Windows loading screen appeared for a few moments, the screen went blank and the system restarted. It was worth a shot.

As the system rebooted, we pressed DELETE to enter the CMOS Setup Utility. Under the Main tab we set the correct time and date and then used the arrow keys to select the Advanced tab. Next we chose to explore the Advanced BIOS Features, which gave us access to the boot

sequence. We made the floppy drive the first boot device, followed by the CD-ROM and hard drive. We opened the DVD-ROM drive, inserted the WinXP Home CD, and then closed the drive tray. We used the arrow keys to select the Exit tab and chose the option to save changes and exit. We pressed ENTER and waited as the system rebooted.

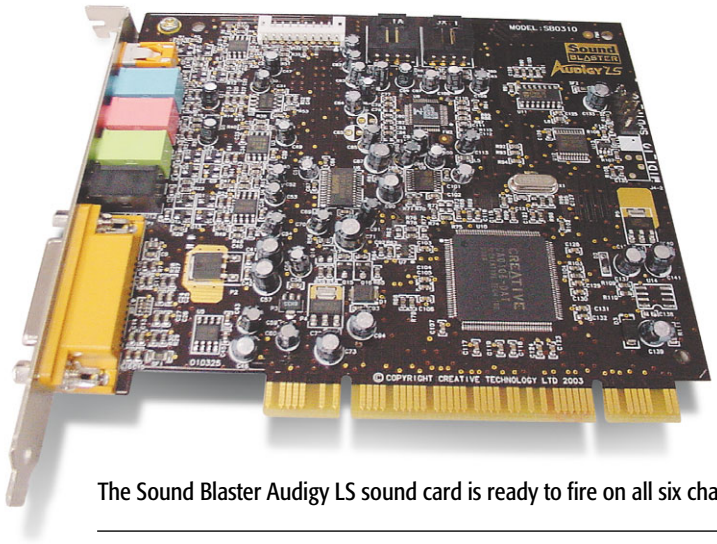
This time we waited until we were prompted to press CTRL-S (or F3) to enter the RAID Configuration Utility. We noted that our Samsung hard drive had been a part of a mirrored RAID configuration in its previous life (it was used to build another system) so we chose the Delete RAID Set option and pressed ENTER. We used the utility to format the drive, just to give us a clean slate. When the drive had finished formatting, we pressed CTRL-E to exit and then the *Y* key for Yes.

When the system rebooted, we waited until we were prompted to press any key to boot from CD, at which time we pressed



The Ideal 5.1 Setup

the Spacebar. At the next prompt, we pressed F6 to indicate that we wanted to install a third-party SCSI device. The next screen displayed the message, "Setup could not determine the type of one or more mass storage devices..." At this point we pressed *S* to specify an additional SCSI adapter. When prompted, we inserted the driver CE and pressed ENTER. We then selected the "Silicon Image Sil 3x12 SATARaid Controller for Windows XP/Server 2003" option from the list of drivers and pressed ENTER to continue. The next screen informed us that Setup would load support for our recognized SATA hard drive, so we pressed ENTER to continue.



The Sound Blaster Audigy LS sound card is ready to fire on all six channels.

The installation process began after we pressed ENTER to Setup WinXP Now. We pressed F8 when prompted to agree to the license terms and then pressed ENTER to install WinXP. The next screen informed us that a new partition had been created for WinXP and now that partition needed to be formatted. We chose to Format The Partition Using The NTFS File System (Quick) and pressed ENTER. Next, the screen informed us that Setup was copying files to the Windows Installation Folders. When the copying had finished, Setup rebooted the system.

We pressed the DELETE key to enter the CMOS Configuration Utility and then pressed ENTER on the Advanced tab to access the Advanced BIOS Features menu. We changed the boot sequence so that our floppy drive was the first boot device, followed by the hard drive and the CD-ROM drive. We went to the Exit tab and pressed ENTER to exit and save our changes. Windows walked us through the rest of the process, including setting the language options, naming the computer, etc., and entering the product key. With WinXP up and running, we installed the mobo drivers and the video and audio card drivers.

We used Doom 3 to test our surround speakers, but while in the audio options menu of the game, we noticed that the PC didn't recognize our surround-sound setup. We exited the game, clicked Start, clicked Control Panel, clicked the link for Sound, Speech, And Audio Devices, and then, under Pick A Task, we clicked Change The Speaker Settings. We clicked the Audio tab in the Properties dialog box, and then we clicked Advanced. On the Speakers tab of the Advanced Audio Properties dialog box, we selected 5.1 Surround Sound Speakers in the drop-down menu of various speaker configurations. We clicked the Apply button and the rear speakers immediately hummed to life. Next we went into the Doom 3 menu and chose Surround Sound Speakers and clicked Apply Changes.

Final Remarks

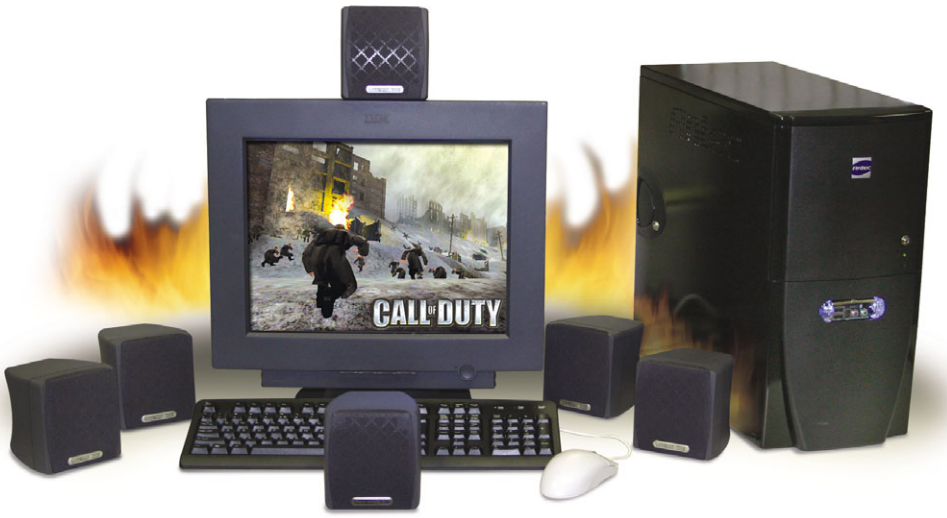
Once everything was in order, our speakers did such a good job with Doom 3's creepy soundtrack that we were almost convinced we'd been teleported to Mars. If you have the money, though, you might consider a higher-end set because although the MidiLand MX-5 system looks sharp, the volume control is tricky. It went from just-not-loud-enough to the-neighbors-are-gonna-call-the-police loud with the slightest adjustment. (You can probably free up some speaker money by getting half as much RAM as we did.) This project didn't start out as a high-end sound system, but it did an excellent job of delivering realistic six-channel audio for a reasonable amount of money. RS

by Andrew Leibman

6.1 Surround-Sound System For Under $1,500

Are You Hearing All There Is To Hear?

Build #46 Skill Level: 1 **2** 3 4 5 ***Apprentice***



If you own DVDs, you may not be hearing all there is to hear. Even if you own a 5.1 surround-sound system, movies with DTS-ES (Digital Theater Systems-Extended Surround) and Dolby Digital-EX soundtracks have audio information that you can only fully experience with a 6.1- or 7.1-channel surround-sound system. If that's not a compelling enough reason to shell out for the full DVD experience, then consider the fact that our seven-channel system cost just slightly more than our six-channel system. Salivating yet?

Goal

The purpose of building a 7-channel surround-sound system is twofold: to enjoy a richer experience from your media than basic 5.1 audio can provide and to blow away the surround-sound systems of your friends and neighbors. We took the design for our 5.1 system and kicked it up a notch, without putting much of a dent in our budget. We had $1,500 to build this system and did it for $70 less than that.

Background

We chose AMD's Athlon XP 3000+ to be the heart of our 6.1 surround system. The 3000+ may not be state-of-the-art, but it served our needs adequately with a 2.16GHz clock speed and 333MHz FSB. With the processor decision made, our list of choices for a Socket A motherboard was long, but we finally settled on the NVIDIA nForce2 Ultra 400-equipped ASUS A7N8X-E Deluxe. The motherboard includes support for DDR 400 dual-channel memory, Dual LAN (10/100, and Gigabit) Ethernet, a Silicon Image Serial ATA RAID controller, and an 8X AGP slot. The motherboard also has an integrated 6-channel sound chip, but as in the case of our 5.1 system, we elected to go with the additional features a standalone sound card provides.

We chose a 1GB dual kit of Kingston DDR 400 memory to occupy the dual-channel slots on our motherboard. We considered forgoing the dual-channel memory kit because it was slightly more expensive than individual sticks, but we decided that the improved throughput was worth the extra expense. If you're more interested in watching movies than playing games, half as much memory is more than enough.

For a video card we settled on the ATI Radeon 9700 Pro, which features 128MB of dedicated video memory, which should ably handle the latest games and DVD movies. Our audio card is Creative's Sound Blaster Audigy 2, which delivers 24-bit Advanced HD audio, support for Dolby Digital 6.1 Surround EX for DVDs, and DirectSound3D decoding for games. We chose Creative Lab's Mega-Works 6.1 surround-sound speaker system for our speakers, which is the suggested speaker set to accompany the Audigy 2 (imagine that).

The hard drive for this system is an 80GB Samsung SATA drive, which we linked to the Silicon Image SATA controller onboard the A7N8X-E Deluxe. We included room in our budget for a floppy drive, which we used primarily for loading the SCSI drivers during the setup process. We wanted to keep our components as straightforward as possible to keep the price down, so we chose an ASUS 16X DVD-ROM drive. This system won't burn DVDs, but it'll play them like nobody's business.

The display we purchased is a recertified 17-inch IBM G78 CRT, with a maximum resolution of 1,280 x 1,024. We chose our Sonata case from Antec's line of quiet Super Mini Towers, which is a piano-black

System Notes

Outstanding Features

The MegaWorks sound system delivers high-quality surround sound with good speaker control. DTS-ES movies and DirectSound3D games sounded spectacular.

Weak Links

The Radeon 9700 Pro stumbled through the testing of Doom 3 and Call Of Duty. Attention video card dealers: Is it so difficult to include a DTS-capable DVD decoder?

steel case that comes with a dual-fan 380W Antec TruePower PSU, as well as front-panel audio, USB, and FireWire ports. The case also features a 120mm exhaust fan that should keep our temperatures in check without much excess noise.

When building a system that could easily exceed our target budget several times over, we had to cut corners where possible. The victims of our skimping were the mouse and keyboard. The no-brand $4 keyboard and $5 optical scroll mouse we purchased will probably get you laughed out of a LAN party but are sufficient for our purposes. As with our previous surround system, we chose Windows XP Home Edition as the operating system.

Parts List

Component	Model	Price
Case	ANTEC Life Style Black Case/380W Power Supply, Model SONATA	$99
Monitor	IBM G78 1280 x 1024 17-inch Flat Black Monitor (Recertified)	$90
Mouse	Optical Scroll Mouse	$5
Keyboard	Keyboard SK-700B	$4
Mainboard	ASUS A7N8X-E Deluxe	$93
CPU	AMD Athlon XP 3000+	$146
RAM	Kingston ValueRAM Dual Channel Kit 1G (512MBx2) DDR PC-3200	$181
Hard Drive	Samsung 80GB SATA Hard Drive	$79
Optical #1	ASUS Black 16X DVD-ROM Drive	$31
Floppy Drive	Mitsumi 1.44MB 3.5-inch Floppy Disk Drive	$13
Video Card	PowerColor Radeon 9700 Pro Video Card	$195
Sound Card	Creative Labs Sound Blaster Audigy 2	$72
OS	Windows XP Home Full OEM Version	$64
Speakers	Creative MegaWorks 7-Piece Speaker System	$265
Software	Call Of Duty: Game Of The Year Edition	$30
	InterVideo WinDVD6 Platinum	$63
Total		**$1,430**

The Build

With all of our components laid out, the first thing we did was remove the side panel of our Sonata case. The interior of the Sonata looked well engineered, with the four internal 3.5-inch drive bays facing the open side of the case. We noted that the rear 120mm exhaust fan had a Molex connector, the spare PSU fan had a 3-pin connector for the motherboard header, and the PSU had two power plugs adapted for SATA devices. A bag of accessories and screws was also included. We made sure to diffuse static electricity by first touching a grounded and unpainted piece of metal, and then we set out the motherboard. We checked the various motherboard accessories and inspected the manual. The A7N8X-E Deluxe included a Quick Setup Guide, which is a very handy step-by-step description of how to build a system using the A7N8X-E Deluxe. In the interests of journalistic integrity (or perhaps fragile male ego), we promptly threw it away. When we were familiar with the mobo, we turned our attention to the CPU.

CPU, heatsink, and RAM. A clean, flat surface is ideal for mounting hardware to the motherboard. The AMD Athlon XP 3000+ processor included the stock aluminum and copper heatsink and detailed installation instructions. We carefully set out the CPU and heatsink and proceeded to follow the instructions. First, we lifted the A7N8X's socket-locking arm to the open position. The processor has a gold triangle at one corner, which should point at the socket arm hinge when properly oriented. We lined up the CPU pins with the socket holes and slid it into place. We then locked the CPU to the socket by lowering the socket arm.

The heatsink's thermal paste was protected by a plastic cap, which we removed prior to placing the heatsink over the CPU. The heatsink connects to the motherboard with a V-shaped clamp, which we lined up with the locking lugs of the socket. The instructions warned us that no part of the heatsink should touch the socket, so we made sure the flat surface was only touching the CPU's four rubber pads. This put the thermal paste directly over the CPU die. We fit the bottom side of the clamp over the socket lugs and then used a screwdriver to maneuver the opposite side of the clamp over the remaining lugs. With the heatsink secure, we plugged the fan into the header labeled CPU_FAN1.

We again diffused static electricity before handling the RAM sticks and opened the ejector tabs. The manual suggested using the two blue slots for dual-channel memory, so we positioned the first stick of DDR400 RAM in the blue slot labeled DIMM_A2, making sure the notch in the module matched the notch in the slot. We pushed the module into place, one edge at a time, until the tabs locked the module down. We followed the same procedure for the second module using the blue slot labeled DIMM_B1, which left the black RAM slot empty.

Mobo and PSU. With the motherboard set in the case, we marked off where we'd have to install standoffs, removed the board, and installed the standoffs. At this point we removed the input/output plate that came with our case and put the one that came with our motherboard on the rear panel connectors. This helped reduce the maneuvering we'd have to do once the board was in the case. The 9.6- x 12-inch motherboard barely fit, so we did our best to hold the input/output plate to the board until we got it past the fan. Next we secured the board to the case with screws. We connected the 20-pin ATX power connector from the PSU to the motherboard. Then we plugged in the system panel connector, which consists of the case's power switch, reset switch, IDE and power LEDs, and internal speaker. Following the diagram in the A7N8X's manual, we matched the leads with the labeled plugs and kept the labels facing outward.

The USB plug from the case's front panel is marked, so we connected it to the header labeled USB56 and then connected the remaining plug (FireWire) to the header labeled IE1394_1. Our front panel audio ports came with a single plug that conforms to Intel's audio connector standard.

Because the FPAUDIO1 headers on the motherboard conform to the same standard, we simply connected the plug. We supplied power to the rear exhaust fan with a Molex plug labeled FAN ONLY. Next we connected the auxiliary PSU fan plug to the header on the motherboard labeled PWR_FAN1. Finally we supplied power to the front panel LEDs with a Molex plug from the PSU.

Drives. We plugged the floppy drive's ribbon cable into the appropriate controller port on the motherboard, making sure the white wire corresponded with pin No. 1 on the plug (which is labeled on the board and in the manual). The IDE cable also has a white wire that corresponds with pin No. 1, so we plugged it into the port labeled PRI_IDE1.

We pinched the release clips on either side of the bottom internal 3.5-inch tray and removed it from the cage. The tray secured to the hard drive through rubber grommets and special screws. We made sure to install the drive so that the rear connectors faced the outside of the case for easy access. Next we connected the SATA cable and slid the tray back into the slot. We then threaded the SATA cable above and behind the drive while routing the SATA power plug in from below the drive. We connected the SATA cable to the SATA port on the motherboard labeled SATA_RAID1.

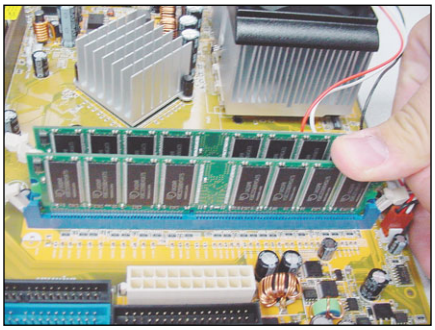
The DVD-ROM drive went in next. We removed the top 5.25-inch drive bay cover and screwed the included drive rails to the sides of the optical drive. We slid the drive into the top bay until it clicked.

Watch Out

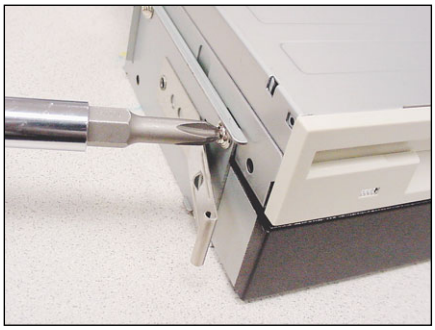
If you have a movie with a 6.1-channel DTS-ES soundtrack, you'll have to look beyond the bundled DVD decoder software that comes with your video card. We checked the Web and found a few products that support DTS, but they cost more than $60 apiece. Are we asking too much to be able to experience everything a piece of media has to offer with nothing more than the necessary hardware? Apparently so. ▲

Next we pinched the clips for the external 3.5-inch drive cage and removed it. We secured our floppy drive to the top slot with four screws and then snapped the cage back into our case. We connected the ribbon cables to both the floppy drive and the DVD-ROM drive and secured power connectors for both drives.

Cards, connectors, and speakers. Next we went about the task of installing the expansion cards. The AGP slot lined up with the bracket second from the top, so we removed it to make room for the input/output ports of our 9700 Pro video card. We again made sure we had dissipated static electricity and then slid the video card in place, securing it to the case with a screw. We removed the bracket that corresponded to the middle PCI slot to make room for the Sound Blaster Audigy 2 sound card. We slid the card into the slot and bolted the bracket to the case, then we connected the 9700 Pro's Molex power plug.



We used the blue DIMM slots to take advantage of the A7N8X's dual-channel controller.



We installed the floppy drive in the top bay of the 3.5-inch drive cage.

Before we could test our new system, we had to create a driver diskette to get the system to recognize our SATA hard drive. We loaded the mobo's included driver CD into another system, inserted a blank floppy in the floppy drive, and right-clicked the drive that contained the CD. We clicked Explore, double-clicked the Drivers folder, and then double-clicked the SATA folder to show us its contents. We selected the nine files we needed (we didn't want the GUI or Linux folders), right-clicked the selected files, and then clicked Send To. We clicked 3.5-inch Floppy and waited for the files to copy to the blank diskette. We labeled the floppy "Manufacturer-Supplied Hardware Support Disk." Trust us, the label is worth the effort.

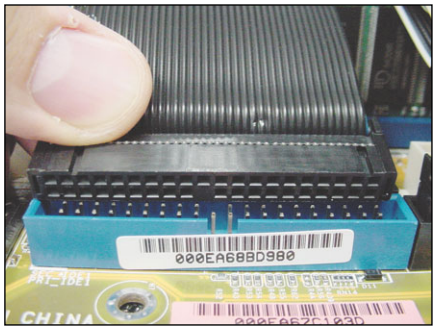
Back at our new system, we plugged the monitor, mouse, and keyboard to the computer, made sure the PSU voltage switch was set to 110, and plugged the PSU power cord to a wall outlet. We configured our Creative MegaWorks speakers in the optimal setup, with the center channel speaker on top of the monitor and the front left and right speakers flanking either side. We positioned the rear left and right speakers approximately 3 feet behind our sitting position. The extra rear channel speaker was also about 3 feet behind us. We aimed the speakers diagonally so the rear left and right speakers faced the front right and left speakers, respectively, while the front and rear center channels faced each other. We placed the subwoofer approximately 8 inches from the computer tower (though ideally it should be in the floor). Next we plugged the speakers and control panel to the subwoofer.

Testing

We turned on the speakers with both a power switch on the back of the subwoofer and the power button on the control panel. We then turned on the monitor to let it warm up. Before starting the system we did one last check of all ports, wires, plugs, and connectors. When we flipped the switch on the PSU, a green LED on the motherboard lit, indicating that the board was getting power. We pressed the computer's power button and watched to make sure the fans started up. (They did.) As the system started we pressed DELETE to enter the CMOS Setup Utility. Under the Main tab,

we set the correct time and date and used the arrow keys to select the Advanced tab. We chose to explore the Advanced BIOS Features, where we changed the boot sequence so that the floppy drive was the first boot device, followed by the CD-ROM and then the hard drive. We put the WinXP Home installation CD into the optical drive and used the arrow keys to select the Exit tab and chose the option to save changes and exit. When we pressed ENTER, the system rebooted.

After the system's POST, we pressed ENTER to boot from CD. When prompted, we pressed F6 to indicate that we wanted to install a third-party SCSI device. The installation process halted when it couldn't find our hard drive. At this point we pressed the *S* key to specify an additional SCSI adapter, which brought up the screen that told us to Please Insert The Disk Labeled Manufacturer-Supplied Hardware Support Disk. We inserted the appropriately labeled floppy and pressed ENTER yet again. We then selected the Silicon Image Sil 3x12 SATARaid Controller for Win-dows XP/Server 2003 option from the



Pin No. 1 is on the left side of the plug.

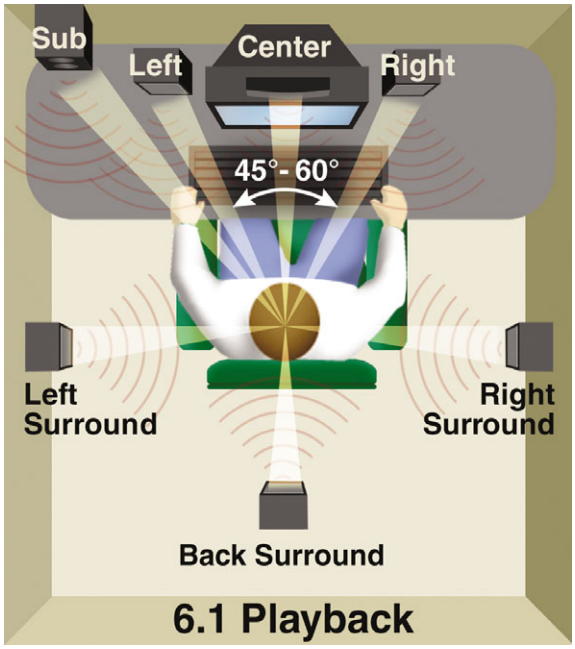
list of drivers and pressed ENTER to continue. We then pressed—you guessed it—ENTER again to load support for our SATA hard drive, after which the Windows installation continued.

Next we were prompted to Setup Windows XP Now, so we did. We pressed F8 to agree to the license terms, and then we installed Windows on the unpartitioned space. Once a new partition had been created for WinXP, we had to format it, which we did by choosing the Format The Partition Using The NTFS File System (Quick) option. The following screen informed us that Setup was copying files to the Windows Installation Folders, after which Setup rebooted the system.

As the computer started, we once again entered the CMOS Configuration Utility. We went to the Advanced tab and selected the Advanced BIOS Features option, after which we changed the boot sequence back to its original configuration (floppy drive first, followed by the hard drive and then the optical drive). Then we exited the utility, saving our changes on the way out. As the Windows Setup process continued, we configured the language settings, named the computer and Administrator, and entered our Windows product key. When the installation was complete, we proceeded to install the motherboard drivers, followed by the video and audio card drivers.

To get our system to play audio using all seven channels, we headed to Windows' Control Panel and clicked Sound, Speech, And Audio Devices. Then, under Pick A Task, we clicked Change The Speaker Settings. We clicked the Audio tab in the Properties dialog box and then clicked Advanced. On the Speakers tab of the Advanced Audio Properties dialog box we opened the drop-down menu of various speaker configurations and found a generic Surround Sound Speakers setting as well as 5.1 and 7.1 settings, but nothing for 6.1 surround sound. For the time being we selected 7.1 Surround Sound Speakers, applied the changes, and clicked OK to exit the menu.

We used the director's cut of "The Lord of the Rings: The Fellowship of the Ring" and listened to the DTS-ES soundtrack, which provides seven channels of audio. Even though our Audigy 2 sound card supports DTS-ES, we still needed a DVD decoder with DTS support. InterVideo's WinDVD6 Platinum filled the bill. At press time, InterVideo's Web site had an offer for a free 14-day trial of WinDVD6.



The ideal 6.1 speaker setup.

The movie sounded better than we remembered it sounding in the theater, which made our 17-inch G78 monitor look all the more tiny and inadequate. We also budgeted for Call Of Duty, a World War II FPS from Activision that supports the Audigy 2's DirectSound3D, and utilizes up to eight channels of surround sound. The game played and sounded superb. In fact, our character took an unreasonable amount of enemy fire just because we liked hearing bullets whizzing at us from all sides.

Final Remarks

This system provides the next technological leap in surround-sound home entertainment. With seven channels, movie sound is more immersive and games more realistic. The Creative MegaWorks speaker system sounded top-notch and only loses points for having a wired remote rather than a wireless one. If you have extra money to spend and are anything more than a casual gamer, we'd recommend stepping up to a more advanced graphics card, as the Radeon 9700 Pro showed its age a bit during our tests using Call Of Duty and Doom 3. All in all, however, the build was a success. RS

by Andrew Leibman

7.1 Surround-Sound System For Under $1,750

Immerse Yourself In Auditory Splendor

Build #47 Skill Level: 1 **2** 3 4 5 ***Apprentice***

Eight-channel surround sound is no longer exclusive to early adopters' and extreme audiophiles' living rooms; you can experience the benefits for less than you think. DTS-ES (Digital Theater Systems-Extended Surround) soundtracks on DVDs provide surround sound beyond 5.1, and Dolby Digital-EX uses the extra speakers by matrixing audio from the rear channel tracks. You can also upmix any recording to utilize all eight speakers, which can add a new depth to your CDs and DVD audio discs. Perhaps the greatest benefit of having a 7.1 surround-sound system is experienced with games that support DirectSound3D (3D positional audio).

Goal

Building the ultimate surround-sound system is a goal in and of itself, but this system is all about watching movies with better-than-theater-quality sound (with nobody kicking the back of your seat or walking in and out in front of you during the show) and being fully immersed in an alien environment (be it the beaches of Normandy or a Martian research facility). If you've been reading our previous surround-sound system articles, you'll notice that to build our 7.1 system, we took the basic design for our 6.1 surround system (built in the previous article) and improved its graphics and audio capabilities. And we did it all for less than $1,750.

Background

We selected the 2.16GHz Athlon XP 3000+, with a 333MHz FSB as the brains behind our eight-channel surround-sound system. The motherboard that would provide the system's backbone had to feature dual-channel memory slots and support DDR 400. We also needed an onboard Serial ATA RAID controller and an 8X AGP slot. We chose the ASUS A7N8X-E Deluxe, which is built around NVIDIA's nForce2 Ultra 400 chipset.

In order to take advantage of our motherboard's dual-channel slots, we needed a dual kit of RAM. A 1GB dual kit of Kingston DDR 400 memory costs slightly more than two individual RAM modules of the same kind, but the benefits are well worth the minimal price difference. If this system was primarily for watching DVDs, we'd be fine with half as much memory.

We purchased the ATI Radeon 9800 Pro. With a solid 256MB of dedicated video memory, this card should provide us with much more than a casual gaming experience. The standalone sound card we chose was the THX-certified Sound Blaster Audigy 2 ZS Platinum from Creative, which supports 7.1 surround sound and includes an internal drive with extra audio ports. The card features 24-bit Advanced HD audio, support for Dolby Digital-EX and DTS-ES surround soundtracks, and DirectSound3D decoding for games. We chose Creative's GigaWorks S750 surround-sound speaker system as the vehicle for our eight-channel audio experience.

We selected an 80GB Samsung SATA drive, which gave us plenty of storage for games and audio files. Because we're utilizing the Serial ATA controller of the A7N8X-E Deluxe, we needed to include room in our budget for a floppy drive. We'll use the floppy primarily for loading the SCSI drivers during the setup process. In an attempt to cut costs where possible, we opted for an ASUS 16X DVD-ROM as the system's only optical drive.

The steel Antec Sonata Super Mini Tower includes a dual fan 380W Antec

TruePower PSU and a 120mm rear exhaust fan, as well as front-panel audio, USB, and FireWire ports. We also liked the blue LEDs built into the front bezel. We picked up a recertified 17-inch IBM G78 CRT monitor, which provided up to a 1,280 x 1,024 resolution.

We ordered the cheapest optical scroll mouse and generic keyboard we could find (less than $10 for the set). In hindsight we should have sprung the extra 50 cents to get the mouse in black. If you're following our budget, we suggest spending the excess on a wireless mouse. Finally, we chose Windows XP Home Edition as our OS.

Parts List

7.1 Surround-Sound System For Under $1,750

Component	Model	Price
Case	ANTEC Life Style Black Case/380W Power Supply, Model SONATA	$99
Monitor	IBM G78 1,280 x 1,024 17-inch Flat Black Monitor (Recertified)	$90
Mouse	Optical Scroll Mouse	$5
Keyboard	Keyboard SK-700B	$4
Mainboard	ASUS A7N8X-E Deluxe	$93
CPU	AMD Athlon XP 3000+	$146
RAM	Kingston ValueRAM Dual Channel Kit 1G (512MBx2) DDR PC-3200	$181
Hard Drive	Samsung 80GB SATA Hard Drive	$79
Optical #1	ASUS Black 16X DVD-ROM Drive	$31
Floppy Drive	Mitsumi 1.44MB 3.5-inch Floppy Disk Drive	$13
Video Card	Radeon 9800 Pro Video Card	$266
Sound Card	Creative Labs Sound Blaster Audigy 2 ZS Platinum	$165
OS	Windows XP Home Full OEM Version	$64
Speakers	Creative GigaWorks Eight-Piece Speaker System	$380
Software	Call Of Duty: Game Of The Year Edition	$30
	InterVideo WinDVD6 Platinum	$63
Total		**$1,709**

The Build

Our first task was to open and inspect the case. We removed the two thumbscrews from the back of the case and unlatched and detached the side panel. The case includes four internal 3.5-inch drive bays facing the open side of the case, two external 3.5-inch bays, and three external 5.25-inch bays. We noted that the rear 120mm exhaust fan had a Molex connector, and the spare PSU fan had a 3-pin connector for the motherboard header. The PSU also had two power plugs adapted for SATA devices, which we used to power the SATA hard drive.

Before touching any of our components, we made sure to diffuse static electricity by touching a grounded and unpainted piece of metal. We started with the motherboard, setting it on the included piece of foam. We checked the various accessories and inspected the manual. Next, we turned our attention to the CPU.

CPU, heatsink, and memory. Following the provided instructions, we set out the CPU and heatsink and lifted the A7N8X's socket-locking arm to the open position. The CPU only fits into the socket one way, so we lined up the processor pins with the holes in the socket and slid it into place. We then locked the CPU to the socket by lowering the socket arm.

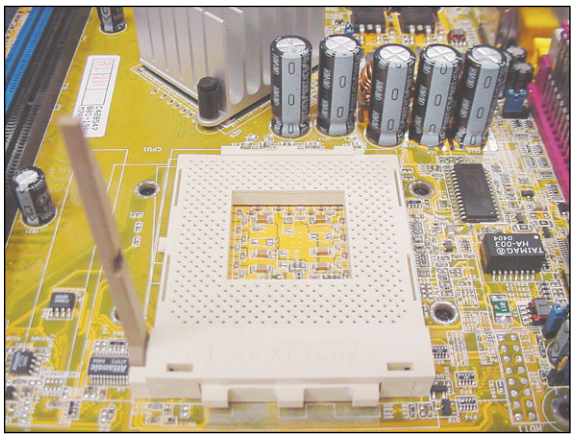
A plastic lid protects the Athlon XP's patch of thermal paste, which we removed prior to installing. The heatsink attaches to the CPU socket with a V-shaped clamp that features three square holes on each side. We latched the small side of the clamp to the locking lugs on the socket. The four rubber pads on the CPU made even contact with the bottom of the heatsink, which put the patch of thermal paste directly over the CPU die. We used a screwdriver to maneuver the opposite side of the clamp over the three socket locking lugs. (Of course, you'll want to practice extreme caution when using a screwdriver on or near any computer components.) With the heatsink mounted to the motherboard, we plugged the fan into the header labeled CPU_FAN1.

We checked the motherboard manual for the proper dual-channel memory configurations and opened the ejector tabs on the blue slots. Before handling the RAM modules, we again made sure to diffuse static electricity. Next, we positioned the first stick of DDR400 RAM in the blue slot labeled DIMM_A2, making sure the keyed module matched the keyed slot. One edge at a time, we pushed the module into place until the tabs locked it down. We then followed the same procedure for the second module using the blue slot labeled DIMM_B1.

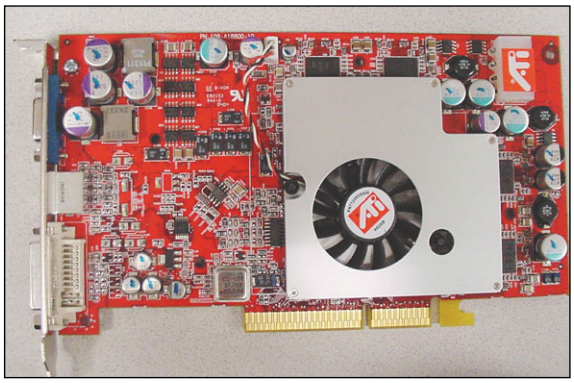
Motherboard and PSU. Our next task was to install the A7N8X in the case. We started by setting the board in the case and noting where to install standoffs. Then we removed the board and installed them, screwing them in by hand. We removed the rear input/output plate that came with the case and replaced it with the plate tailored for the input/output ports of the motherboard. We put the motherboard in the case at an angle and lined up the back panel first. When the board was in place, we secured it to the case with the included screws. Next, we supplied the power to the motherboard with the 20-pin ATX power connector from the PSU. The system panel connector is a series of plugs that consists of the case's power switch, reset

Watch Out

While testing Call Of Duty and Doom 3, the Radeon 9800's VPU continually reset. The same problem happened with the Radeon 9700 we were using in our 5.1 and 6.1 surround-sound systems. After a quick Web search, we determined that the games might perform better with an updated driver. We went to www.ati.com/support/infobase/4547.html and downloaded a beta version of ATI's Catalyst 4.9 graphics driver, which is reportedly better able to handle Doom 3. The driver seemed to do the trick. If you're a serious gamer and have some room in your budget, the NVIDIA GeForce 6800 series of video cards are rated as ideal for Doom 3. ▲



The socket arm is in the open position.



The Radeon 9800 Pro has a rather plain-looking heatsink.

switch, IDE and power LEDs, and internal speaker. We referred back to the motherboard manual for the proper plug configuration. We matched the leads on the lower-right corner of the board with the labeled plugs, making sure to keep the labels facing outward.

We connected the USB plug to the header labeled USB56. Next, we connected the FireWire plug to the header labeled IE1394_1. The front-panel audio plugs from the case were configured as a single plug, so we connected it to the motherboard header labeled FPAUDIO1 and then connected the auxiliary PSU fan plug to the header on the motherboard labeled PWR_FAN1. Finally, we supplied power to the front-panel LEDs with a Molex plug from the PSU.

Drives. We chose to install the floppy and IDE cables after mounting the board, applying just enough pressure to connect the plugs without overly stressing the circuit board—too much pressure on an unsupported part of the motherboard could break it. The ribbon cables that came with the A7N8X were black, with Pin 1 denoted by a white wire. We made sure to line up the white side of the cable with the part of the plug marked with the number 1.

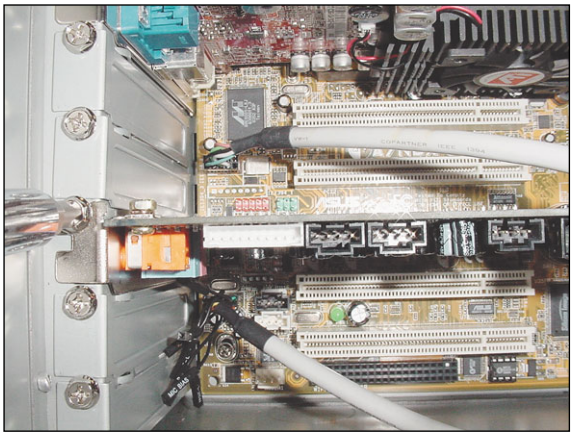
Next, we turned our attention to the bottom internal drive tray. We released the clips on either side of the 3.5-inch tray and removed it from the cage. We mounted the SATA hard drive with special screws that went through rubber grommets on the bottom of the tray. We made sure the drive was oriented in the tray so that the rear connectors faced the open part of the case. We slid the tray into the slot and then routed the SATA power connector and thin SATA cable in from behind the drive. With the plugs connected, we attached the thin SATA data cable to the SATA port on the motherboard labeled SATA_RAID1.

We then installed the graphics and sound cards in the PCI expansion slots. The AGP slot lined up with the second rear bracket from the top, so we removed the screw and bracket to make room for the Radeon 9800 Pro's input/output ports. After touching a grounded piece of metal, we slid the video card in place, securing it to the case with a screw. Removing the corresponding rear bracket beforehand, we installed the Audigy 2 ZS sound card in the middle PCI slot. We slid the card into the slot and bolted the bracket to the case. Next, we plugged a Molex power plug into the Radeon 9800 Pro. Finally, we used a Molex plug from the PSU labeled FAN ONLY to power the rear exhaust fan.

The external 5.25-inch drives came next. The Audigy 2 ZS Platinum has a special ribbon cable that looks like a normal IDE cable but is designed to fit only the leads on the drive and sound card. We plugged this cable, along with the FireWire cable, into the drive's headers prior to installation. Next, we removed the bottom 5.25-inch drive bay cover, took the purple drive rails from the back of the cover, and installed them on the sides of the drive. Minding the cables, we inserted the drive into the empty bay until it clicked into place. We connected the drive's ribbon cable to the header on the sound card and plugged the FireWire cable to the port on the sound card labeled SB1394. We powered the drive with a small power plug from the PSU.

We screwed the drive rails from the top drive bay cover to either side of the DVD-ROM drive. We slid the drive into the top bay until it clicked. Then we removed the 3.5-inch drive cage (pinch the clips and pull), removed the screws holding the top bay cover in place, and installed the floppy drive in its place. We slid the drive cage back into the bay until it clicked and connected the ribbon cables to both the floppy drive and the DVD-ROM drive (making sure the white wire aligned with Pin 1). Then we connected the appropriate power plugs to the floppy and optical drives.

In order to get our system to recognize the SATA hard drive, we needed to create a driver diskette. We loaded the mobo's driver disk into another system, inserted a blank floppy in the floppy drive, and right-clicked the CD drive in My Computer and



Our full-featured sound card had more ports than we knew what to do with.

System Notes	
Outstanding Features	The Creative GigaWorks S750 speakers delivered the best sound of any system we tested.
Weak Links	The Audigy 2 ZS Platinum was a bit pricey, so go for the non-Platinum version and save yourself some money. We also suggest getting a video card that works well with the games you like to play.

clicked Explore. We clicked through the Drivers folder and the SATA folder, selected the nine files we needed (not the GUI or Linux folders), and sent them to our waiting floppy. When the driver disk was ready, we removed it and set it aside.

Speakers and such. We populated our testing area with the GigaWorks S750 speakers in the ideal setup. The front left and right speakers flanked either side of the monitor while the center-channel speaker sat on top of the monitor. The left and right surround speakers were roughly three feet to the left and right of our sitting position. The rear left and right speakers were about 3 feet behind our chair. We aimed the front and rear speakers diagonally so the rear left and right speakers faced the front right and left speakers, respectively. The subwoofer was on the floor to our left. We plugged the speakers and control panel to the subwoofer and fed the subwoofer power cable to an open outlet.

Before we could start the system, we plugged the monitor, mouse, and keyboard into the computer, made sure the PSU voltage switch was set to 110, and plugged the PSU power cord to another outlet.

Testing

We powered the subwoofer and speaker control panel and turned on the monitor. We did one last check of all ports, wires, plugs, and connectors, and when we were confident that we hadn't missed anything, we flipped the switch on the PSU. The onboard LED lit up, which was a good sign. When we pressed the power button, we noted that the fans started spinning. We immediately pressed DELETE to enter the CMOS Setup Utility and headed to the Main tab to set the correct time and date. In the Advanced tab, we selected Advanced BIOS Features, where we changed the boot sequence so that our floppy drive was the first boot device, followed by the CD-ROM and hard drive. We loaded the WinXP Home installation CD, used the arrow keys to select the Exit tab, and chose the option to save changes and exit. When we pressed ENTER, the system rebooted.

When we were prompted, we pressed ENTER to boot from CD and pressed F6 to indicate that we wanted to install a third-party SCSI device. When the system notified us that it didn't recognize our hard drive, we pressed *S* to specify an additional SCSI adapter; WinXP then told us to insert the Hardware Support disk. We loaded the aforementioned driver disk at this point and pressed ENTER. Then we selected the Silicon Image Sil 3x12 SATARaid Controller For WinXP/Server 2003 option from the list of drivers and pressed ENTER again. We loaded support for our SATA hard drive, after which the WinXP installation continued.

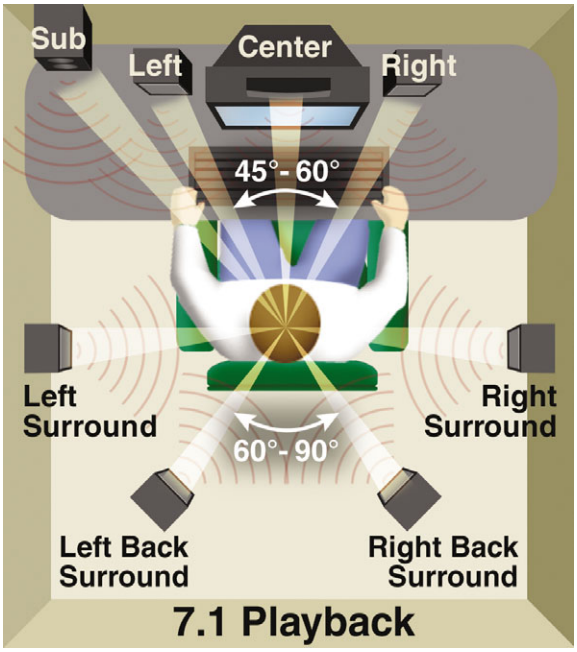
When prompted to begin WinXP setup, we agreed to the license agreement and installed Windows on the unpartitioned space. When a new partition was ready, we formatted it using the quick NTFS option, rebooted, and re-entered the CMOS utility.

At the Advanced tab, we reset our boot sequence to its original configuration in the Advanced BIOS Features box (floppy first and then hard drive and CD-ROM), and saved our changes before exiting. After rebooting, the setup process continued. We configured the language settings, named the computer and Administrator, and entered in the product key. When the installation was complete, we installed the motherboard, video, and audio drivers.

To set WinXP for 7.1 audio, we opened Control Panel; clicked Sound, Speech, And Audio Devices; and then, under Pick A Task, we clicked Change The Speaker Settings. We clicked the Audio tab in the Properties dialog box and clicked Advanced. On the Speakers tab of the resulting dialog box, we selected the 7.1 Surround Sound Speakers setting in the Speaker Setup drop-down menu, clicked Apply, and clicked OK.

Final Remarks

7.1 surround sound is the ultimate in PC audio for DVDs and games. The GigaWorks S750 speaker system delivered the most articulate sound field we've yet encountered. In Call Of Duty, weapon fire from any direction was instantly recognizable, down to the type of weapon the enemy was using. One particularly memorable firefight had us feeling vulnerable in an open field, while mortars exploded and bullets snapped the ground from all sides. We had a problem with the Radeon 9800 Pro's VPU resetting, but performance improved after we installed an updated driver (see our "Watch Out" sidebar for more info). We suggest buying a graphics card that has been tested to perform well with the games you plan to run on your system. RS



The ideal 7.1 speaker setup.

by Andrew Leibman

Best AMD Gaming PC For Under $1,000

You Don't Have To Pay To Play

Build #48 Skill Level: 1 **2** 3 4 5 ***Apprentice***

Gaming is no longer a minor subculture among PC users. Everyone knows that kids play games, but so do moms, dads, and investment brokers with too much time on their hands at the office. PC makers have noted this trend, offering customized PCs designed specifically to handle the graphics and sound-intensive effects that bog down average boxes.

The downside is that gaming PCs tend to swallow technology budgets whole. For example, Alienware, which makes high-octane gaming PCs, sells its Area-51 box for about $3,000. That's too much for even many hardcore gamers to spend on their obsession. We can help.

Goal

We set out to build an AMD gaming system for under $1,000. We didn't want to settle for a machine that could play some, but not all, games on the market. We wanted a gutsy gaming PC that would load and execute Far Cry and Battlefield Vietnam like they were DOS-era versions of Frogger.

We knew we'd have to make budget cuts somewhere, and as you'll soon see, we did have to scale back on our plans for an Area-51 lookalike. But you might be surprised at the power we managed to incorporate into our case in spite of our limited funds.

Background

Our $1,000 budget restriction meant that there would be no Pentium 4 3.60GHz for us. Instead, we wanted to use a CPU that had plenty of speed to burn but at an economical price. We were tempted to buy a Pentium 4 2.8GHz, which at this writing was one of the best buys on the CPU market when you consider its power to price ratio.

In the end, Intel's higher processor prices pushed us to the AMD side. We settled on a bargain-priced AMD Athlon XP 3000+ with 400MHz frontside bus speed.

Then we needed to find a righteous motherboard worthy of power gaming. That meant passing on clone mobos with iffy chipsets and low-quality components. We also wanted a mobo that could handle 1GB of fairly fast memory and one that would support a speedy SATA hard drive. Using those guidelines, we found an ASUS A7V600-X mobo for less than $70.

Finding fast RAM at a decent price was more of a challenge. There was no sense in letting our frontside bus speed go to waste, so we preferred DDR400 modules, and for a gaming machine, there was no reason to go under 1GB of total memory. The problem here was obvious—we were a long way from completing our budget-conscious parts list, but that kind of RAM costs nearly $250. After scouring the Web for lower prices, we eventually settled on a brand name, Corsair, but we went with the company's Value Select line instead of high-end gaming memory. This choice still cost us nearly $200.

We couldn't afford to buy a top-notch video card. Sure, we would've loved to see an NVIDIA GeForce FX 5950 sprouting from our AGP slot, but there was no way we could justify the price. Instead, we selected an ATI Radeon 9800 Pro with 256MB of onboard memory and S-Video and DVI connectors. This card doesn't have the cutting-edge technology you'd expect in a high-priced gaming machine, but as of press time, this was one of the best buys we could find online.

When it came to gaming devices, we wanted a Logitech Extreme 3D Pro

Watch Out

Our ASUS mobo's manual recommended only certain brands and specific models of RAM for optimum performance. Our Corsair RAM worked flawlessly, but using RAM not approved by ASUS may cause system glitches. ▲

Bling Bling

Admittedly, our audio system was far weaker than most high-level gaming systems, but our very restrictive budget didn't leave much room for compromise. The good news is that if you have even $50 to spend on speakers, you won't have problems finding a multichannel system that includes a subwoofer. ▲

joystick to help us take command. Unfortunately, this wasn't meant to be. Budget restrictions limited us to a Logitech Wingman Precision game pad—not our first choice by any means, but it will do the job for just about any game until we pinch enough pennies for a superior controller.

Thrifty & nifty. To help our games produce lifelike and life-loud explosions, screams, and strafing sounds, we wanted to connect a nice, 5.1-channel speaker system that would completely immerse us in the action.

There are plenty of excellent and affordable speaker systems available on the Web—take, for instance, the Logitech Z640 system, which sells for less than $50 yet still garners rave reviews from budget-minded gamers. Sadly, we couldn't afford to spend even that kind of lunch money on our audio setup. With only 20 bucks left on the company tab, we bought Creative's SBS270 speakers, a 2.0 system that's received plenty of compliments on its clean, clear sound.

That frugality came in handy when we went hard drive shopping. We obviously didn't need an old-fashioned IDE, 5,400rpm behemoth for gaming; no matter how much space such a drive might offer, capaciousness is no substitute for speed. We also knew we could get a nice, high-capacity SATA drive with a faster spin rate to keep our games running without a hitch. But during our Web shopping spree, we heard a Raptor calling our names. So after giving common sense and reason a good shove off of our office desks, we rolled the dice and bought a 10,000rpm Western Digital Raptor. At less than 40GB, this drive has enough capacity to make a nice home for several of your favorite games and enough speed to make every hard drive-based application scream for mercy.

After all this excitement we realized that our baby still needed an optical drive. It couldn't be just any old CD-ROM drive, either, because megabyte-heavy games and applications need access to DVD features. We picked an OEM Samsung drive with high-speed CD writing capabilities and decent DVD read speeds.

You'll notice that we didn't mention our case of choice during the parts round-up. The case and power supply we originally selected totaled only $30 during a Newegg sale. Unfortunately, after we ordered most of our parts, Newegg notified us that the super-cheap Pro Source ($30) case we ordered wasn't available. Because that was the only case we could find with an integrated 350-watt PSU, we had to make a last-minute switch to a case we already had in the office, a nice Antec case that went for $64. That meant, of course, that we blew our budget, but only by 30 or so bucks, and it also meant that we got a more reliable PSU to boot.

The Build

We unpacked our various components and slipped the motherboard inside our Antec case. Our standoffs needed adjusting, and we also had to swap out the case's motherboard panel to replace it with the one that ASUS provided. After we dropped in our CPU and secured it using the ZIF lever, we opened up the packages containing our nonrecommended RAM, gave each module a little good-luck kiss, and inserted them into the two slots closest to the CPU socket, making absolutely sure that each was fully seated.

Because our OEM CPU didn't come with a heatsink and fan, we used our sticky fingers to snag one from another system. Budget-wise, this is no back-breaker, as stock AMD heatsinks are inexpensive.

We installed our 9800 Pro in the AGP slot, taking care not to snag any other wires with its extra-long circuit board. Because this card requires extra

Parts List

We killed our budget here, in part due to getting taken by a Windows counterfeiter. A less expensive case would've dropped this one much closer to the target price.

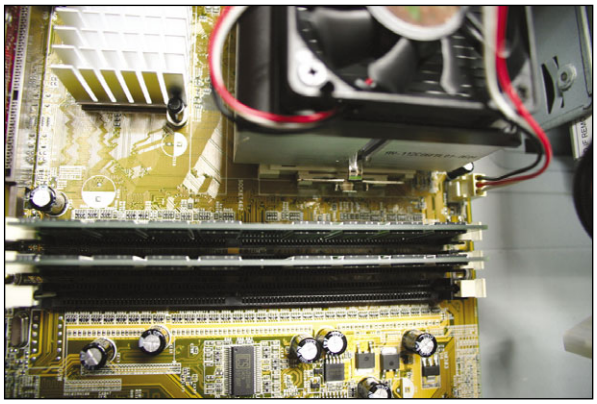
Component	Model	Price
Case	ANTEC Solution Series Super Mid Tower Case with 350W Power Supply	$64
Motherboard	ASUS A7V600-X KT600 Motherboard for AMD Socket A	$67
Processor	AMD Athlon XP 3000 (400 FSB)	$135
Memory	Corsair 1GB Kit DDR400 PC3200 CAS3 Value Select Memory	$175
Hard Drive	Western Digital Raptor 36.7GB 10,000rpm SATA Hard Drive	$112
Video Card	ATI Radeon 9800 Pro Video Card, 256MB	$265
Optical Drive	Samsung Combo Drive: 52X/32X/52X CD-RW & 16X DVD-ROM	$48
Monitor	Dell E773c 17-inch 1,024 x 768 Monitor	$60
Floppy Drive	Generic Floppy Drive	$7
Mouse	Generic Optical Mouse	$5
Keyboard	Generic PS/2 Keyboard	$4
Operating System	Windows XP Home Edition	$90
Joystick	Logitech Precision Gamepad	$10
Speakers	Creative SBS270 2.0 Speakers	$18
Miscellaneous	SATA Power Cable, AMD Heatsink*	
Total		**$1,060**

* Equipment previously purchased.

power, we connected it to one of our PSU's connectors.

Next, we secured our drives to the case brackets using case screws. We took our skinny red SATA data cable, connected it to the back of the hard drive, and plugged the other end into the motherboard's clearly marked SATA 1 connector. For the optical drive, we retrieved an IDE cable and connected the keyed plug to the back of the drive. The other end of the IDE cable went to the blue IDE 1 connector on the motherboard. Finally, we found a floppy drive cable and, after taking a close look at it, connected the twisted end (with gaps in the cable) to the drive. The other end plugged into the mobo's floppy connector, which was adjacent to the IDE connectors.

We connected one of the power supply's regular Molex connectors to the back of the optical drive. Then we sifted through the PSU's cables until we located the small floppy drive power cable, which we connected to the back of the drive. And for the hard drive, we pilfered a pass-through Molex/SATA power cable from one of our co-worker's machines, connected one end to a PSU connector and the other to the SATA power connector on the drive. If you don't have this adapter, you can plug into the drive's traditional four-prong power connector.



We inserted our RAM modules in the slots closest to the CPU socket. Our RAM wasn't recommended for this mobo, but it worked just fine.

For our next few steps, we opened the motherboard's manual to look for connector diagrams. First, we connected the PSU's ATX power cable to the motherboard. Second, we took the case's power switch wire and plugged it into the two rusty-orange-colored connectors on the mobo.

System Specs

A nicer monitor would've been great, but smooth gameplay seemed more important than a large display. A few bucks more would've scored a much better speaker system.

ASUS with VIA KT600 + VT8237 chipset and 400MHz FSB

Six PCI slots and one AGP 8X slot

Eight High-Speed USB 2.0 ports, four on rear mobo panel

ADI AD1888 6-Channel Audio

2x Serial ATA, RAID 0/1

Western Digital 10,000rpm SATA hard drive with 8MB cache

Testing

With all of our connectors and drives in their correct spots, we closed up the case, connected our monitor and various input devices, and pressed the power button. The machine sprang to life and loaded the BIOS menu.

Using the arrow keys, we selected the Boot menu and then used the plus (+) and minus (-) keys to change the drive boot order. We assigned the CD drive as the first boot drive, then the hard drive, and finally, the floppy drive. Then we pressed the F10 button to save our changes and exit the menu.

The computer read our Windows XP installation disc and started the setup process. Unfortunately, WinXP couldn't recognize our SATA hard drive, meaning we had to create a floppy disk with the necessary drivers on it before we could continue. To make this disk, we inserted our ASUS driver CD into another computer and used Windows Explorer to open the DriverDisk folder. Then we inserted a blank floppy disk and double-clicked the MakeDisk icon. This process copied the necessary driver files to the disk.

We restarted our gaming system with the WinXP setup CD in the optical drive. This time, when the bottom of the setup screen prompted us to load SCSI or RAID drivers, we pressed F6 so that we could load our SATA drivers. Then we pressed the *S* key to specify that we wanted to install an additional driver. We inserted our driver diskette and pressed Enter. From the list of drivers, we selected VIA ATA/ATAPI Host Controller (Windows XP) and then VIA Serial ATA RAID Controller (Windows XP); we loaded both just to make sure we loaded the correct driver the first time.

When the setup prompted us to select a drive for our installation files, we chose drive C:. We weren't interested in creating a partition, but if you are, this is where you'll do it. We moved on to the formatting process, and we choose the quick NTFS format option to speed things up. Once the drive was formatted, WinXP copied files to the hard drive and then restarted the PC. During the setup, we were prompted to enter the license code for our copy of WinXP. It was then we found out that our copy was already registered, meaning we'd received a pirated version of the OS. We called Microsoft, got a refund, and bought elsewhere.

More drivers. After redoing the installation with a valid WinXP CD, our computer started up correctly and loaded WinXP. We immediately connected to the Web so that we could download and install a full slate of Windows updates. Once this process was complete, we tried to run our benchmark programs. Unfortunately, these programs refused to execute, citing a number of different errors.

We backtracked to the Device Manager and found yellow exclamation marks hiding several of our system's components. We right-clicked each device and selected the Update Driver option. For the video

card, we inserted the ATI driver disc and let WinXP automatically find and install the driver. We repeated this process for the other malfunctioning components, only we inserted the ASUS driver disc instead. Because there were several drivers listed for every device, we checked the path name of each driver to locate the correct driver for WinXP. After a few minutes, every device was working just right.

PC in chains. Once we updated our machine and installed a few necessary programs, we launched our primary benchmarking application, PCMark04. We selected every benchmark and then executed the tests. Then we waited. And waited. When the results finally came back, our final PCMark score was a lowly 1846. Our hard drive wasn't suffering much, as it kicked back a score of 5482, but obviously, something was very, very wrong with our supposedly powerful gaming machine.

Once again, it was time to review our actions and find out where we went wrong during the construction process. We right-clicked the My Computer icon and selected Properties and found that our CPU was running at only 1GHz. This particular CPU should've been running at 2.15GHz. Oops, time to go back under the hood.

Time-saver

Don't forget to check the CPU Speed option in the BIOS. Our ASUS motherboard kept the CPU speed low to make sure the computer booted properly for operating system setup but never adjusted once we were up and running. If you don't change the speed setting, your computer will run much slower than it should. ▲

We restarted our ailing monster, and during the startup, we pressed the DELETE key to enter the BIOS menu. On the Advanced menu, we selected the CPU Speed option and changed the speed to 2100MHz. Then we saved our changes and exited the menu. After the computer finished starting up, we right-clicked the My Computer icon, and this time our CPU speed was correct.

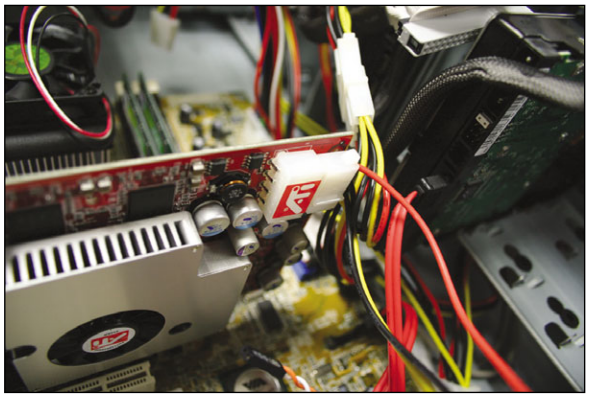
Satisfied, we reran our benchmarking applications to see how much better our scores would be. As we predicted, we saw a marked improvement. Our PCMark 04 score was 3504, and our 3DMark score was excellent, too, with the final number at 5187.

The real tests. We'd be negligent in our testing duties if we didn't install a few graphics-heavy games to see just how well our system would handle some serious fun. So that's exactly what we did. But before we got started, with heavy hearts, we plugged in our two dinky speakers. We cranked the volume to maximum and then backed off a bit.

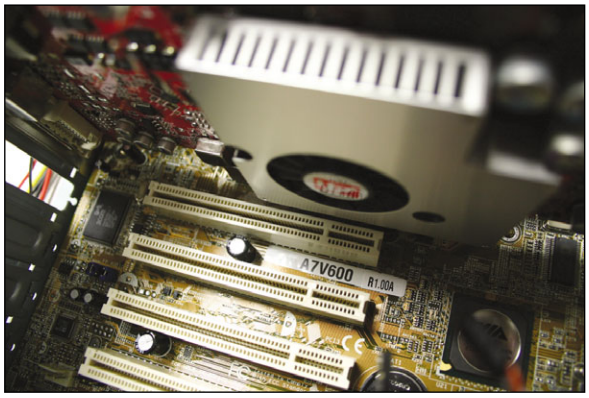
Then we loaded Far Cry. If you haven't played this particular adventure game, it features a first-person point of view, lots of engaging fight sequences, dramatic music, and detailed graphics. When we sifted through the game's Option menu, we noticed that the application automatically selected Medium detail levels for optimum game play.

Undeterred, we bumped the setting up to High and dove into play time. During the game's high-resolution introduction, we noticed no hiccups in graphics or sound, and even rapid panning and fast action looked superb. Then it was time to wander through the game's labyrinthine, three-dimensional environment. We spun our character around and around, ran him full-tilt through debris-strewn tunnels, and noticed no problems whatsoever.

Our Creative Labs speakers were a definite weak point during our gaming sessions. For low-volume sound effects and music, these speakers had clear, dynamic sound. But during segments that should've included loud thumps and explosions, our sub-less system couldn't deliver the gut-punching effects that add a big touch of realism.



Don't forget the power. Our 9800 Pro video card required a power connector from the PSU for extra juice.



Feelin' lucky? The 9800's huge girth is enough to obstruct a PCI card slot. In addition, the 9800's extra length could easily cause space restrictions inside your case.

Final Remarks

We were pleased with the performance we saw from our gaming system. Even though we only spent about $1,000, we managed to cobble together a machine capable of handling some of the most intense games currently on the market.

If we wanted to try a different setup, we would've bought a cheaper, 7,200rpm hard drive and transferred those savings to a slightly more expensive video card and faster CPU. We would also attempt to buy a slightly larger CRT monitor to make our games more visually immersive. But you get what you pay for, and for $1,000, we have very few complaints about this zippy setup. RS

by Nathan Chandler

Best Budget Intel Gaming System Under $1,000

Can You Buy A Really Good Doom 3 Rig For Less Than A Grand?

Build #49 Skill Level: 1 2 3 4 5 ***Master***

Would you rather sit by listlessly watching a movie you'll be bored with two hours later or be actively engaged in a game that could take as many as 20 to 30 hours to play to completion? Most likely you wouldn't be reading this article if you if preferred popcorn and a movie to a sweaty mouse and an itchy trigger finger. Unfortunately, gaming isn't always easy on a budget. We set out on a challenge to build the best gaming system we could for under $1,000.

Goal

Our goal was to create a complete system (including monitor and speakers) that would let us play the latest and greatest games on the market. As luck would have it, Doom 3 was released as we were finishing our system, and we couldn't think of a better test. Our $1,000 budget simply isn't enough to buy the kind of components Doom 3 really wants, but if we could build a system that could deliver decent frame rates at lower resolutions, we'd consider it a victory.

Background

We wanted to buy the fastest processor and video card we could afford without completely decimating our budget. We settled on a 3GHz Pentium 4 (Northwood) for $209 and an AOpen GeForce FX 5700 video card with 128MB of memory for $123.50. Had NVIDIA's GeForce 6600GT been available at the time, we would've taken a serious look at this card and possibly cut back on our processor to work it into our budget. We spent a third of our budget on these two components. One-third may not sound like much, but when you only have $1,000 to spare, it's quite a bit. We had just a little more than $666 to spend on our motherboard, memory, case, monitor, speaker system, and peripherals.

Because we bought an OEM P4, our processor didn't come with a heatsink and fan. We splurged a bit on the Thermaltake P4 Spark 7+. The all-copper heatsink is a better conductor of heat than the aluminum used in Intel's stock heatsinks. Not only that, the Spark 7+ includes a faster, more powerful fan, and the Spark 7+ will look better through our side window.

For the motherboard, we settled on Chaintech's 865PE-based A865PE. The 865PE chipset is Intel's midrange motherboard chipset, and its price-to-performance ratio makes it extremely popular with enthusiasts. In terms of performance, the 865PE comes close to Intel's high-end 875P, but it's significantly less expensive. Chaintech boards have provided us with impressive performance scores in the past, and we hoped the A865PE would provide us with the most performance we could get for $89. We added two sticks of 256MB PC3200 DDR SDRAM, giving us a total of 512MB and allowing us to use dual-channel memory.

Like most motherboards, the A865PE includes integrated sound and Ethernet. We took advantage of the native audio and Ethernet support, saving us from spending additional money on a sound card or network card. As you'll see, we didn't end up having room for either in our budget.

We used a single Western Digital 7,200rpm SATA drive for our primary storage. 80GB isn't a whole lot, but it should be enough to get you started, and the $69.99 price fit our budget perfectly. Besides, we could always add extra storage later if we really needed it. Prices on DVD burners are coming down dramatically,

and our NEC 8X DVD±RW drive cost us just about $30 more than we would've spent on a CD-RW drive. Our Chaintech A865PE will let you install Windows XP without third-party drivers, so there was no need for a floppy drive. Nonetheless, you never know when a floppy drive might come in handy, and at $10.99 for a black NEC floppy drive, we were able to fit the floppy drive into our budget.

It's important for a gaming system to look as good as it runs. With our limited budget, however, high-end cases from Thermaltake, Cooler Master, or Lian Li were out of the question. The RAIDMAX Aluminum Gaming Case 668WPB, however, looks like a high-end gaming case; but at $78 (with a powerful 420W power supply), it's well within our budget. The case is extremely light, making it easy to take your system to LAN parties. Colored LEDs on the fans, a see-through window on the left-side panel, and a black and red color scheme complete the look. The case is also easy to work with. Removable hard drive trays make adding hard drives quick and easy. The front of the case swings open, making it easy to add 5.25-inch and 3.5-inch drives. It's even easy to remove the rear expansion slot covers.

Our case is not only lightweight, but it also looks sharp and includes a side glass panel, side fan, and case fan LEDs. Not bad for $78.

We didn't have much left to spend on a keyboard and mouse, so we opted for a black Keyboard-2000 Smart 1 package for $10. The keyboard is decent, but the mouse included in the package is an old-school mouse. We replaced the included mouse with a Logitech MX500 optical mouse. We also bought a Cintre RW-6580 5.1-channel speaker system. The system isn't the greatest, but it set us back just $35.50.

We found a refurbished 17-inch IBM monitor from TigerDirect.com for $79.99 that would fit within our budget. We, however, used a spare 22-inch monitor we had hanging around our labs (hey, just because *you're* on a budget doesn't mean we need to be, too).

And, of course, don't forget about an OS. We picked up an OEM copy of WinXP from Newegg.com for $90. When all was said and done, we had spent a grand total of $995.95 on our budget gaming system, leaving us just $4.05 under our $1,000 budget.

The Build

We started with the case, and it was at this time that we noticed just how light the case is. It didn't feel as solid as some of the other cases we have used, but its light weight more than made up for it. The left-side panel was secured by four thumbscrews that we easily removed, and the side panel swung open easily. We removed the hardware inside and set the case on its side.

We opened our Chaintech A865PE motherboard and placed it inside the case. We noted positions where we needed to mount standoffs and removed the motherboard. We screwed the standoffs to the back of the case and turned our attention to the motherboard.

It's usually easier to install the processor, heatsink, and memory before we install the motherboard, so we lifted the handle next to the socket, dropped in our P4, and lowered the handle to lock the processor in place.

We added a small amount of thermal paste in the middle of the heatspreader that covers the P4 die. Our Spark 7+ heatsink fit nicely over the processor. We locked the heatsink in place by latching two metal clamps to the heatsink frame. Make sure the clamps face opposite directions. Connect the yellow wire to the 3-pin CPU fan header on the motherboard to monitor the fan's rpms.

We lined up the notch in each memory module with the notch in the memory slot on the motherboard and pressed each module firmly until the clips along the side locked into place. To take advantage of dual-channel memory, we installed each module into the blue slot on the motherboard.

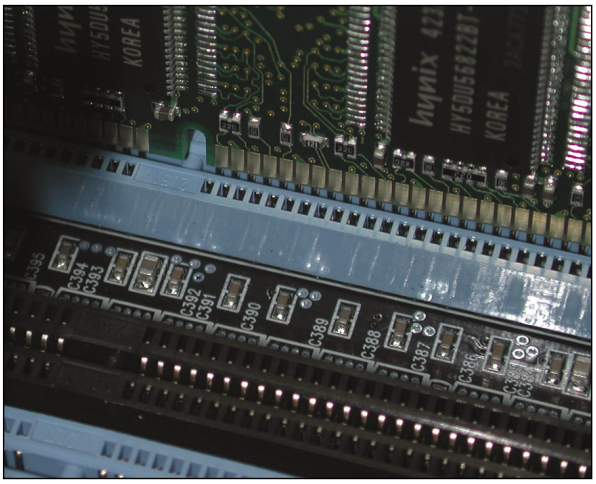
Our next step was to secure the motherboard to the standoffs we installed earlier using screws included with the case.

System Notes	
Operating System	Windows XP Home
Processor	3.0C GHz Pentium 4
RAM	512MB PC 3200 DDR SDRAM
Bus Speed	800MHz
Hard Drive	80GB SATA
Optical Drive	8X NEC DVD±RW
Connectivity	10/100 Ethernet
Video Card	NVIDIA GeForce FX 5700
Video RAM	128MB
Monitor	17-inch CRT
Sound Card/Speakers	5.1-Channel Surround Sound
Chassis Size (inches)	20.5 x 8 x 18.5
Weight	25 lbs
Benchmarks	
3DMark03	3273
PCMark04	4517
CPU Score	4641
Memory Score	4585
Graphics Score	3019
HDD Score	4224
Doom 3	
Medium Quality	
640 x 480	42.6fps
800 x 600	35.4fps
1,024 x 768	24.6fps
1,600 x 1,200	11.6fps
High Quality	
640 x 480	37.3fps
800 x 600	29.2fps
1,024 x 768	21fps
1,600 x 1,200	10.7fps
Ultra Quality	
640 x 480	31.8fps
800 x 600	24.9fps
1,024 x 768	18.2fps

Before the case gets too crowded, it's a good idea to wire the power switch and LEDs to the front-panel connector on the motherboard. Use the diagram included in the motherboard manual to connect the proper leads to the proper pins. Pay attention to negative and positive pins. The colored wire on the lead corresponds to the positive pin on the connector, and the black wire corresponds to the negative (or ground) pin.

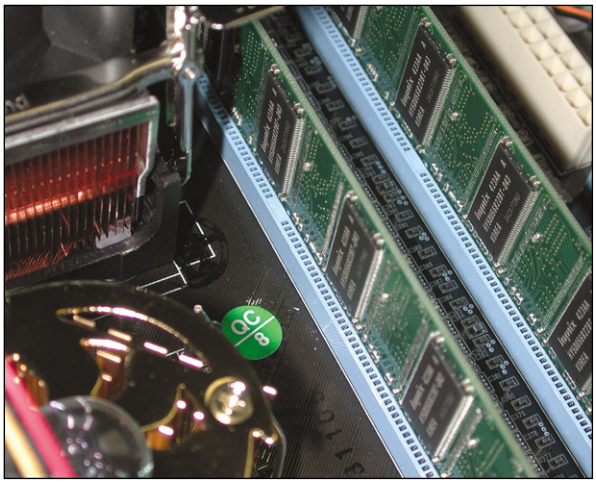
Next, we connected the USB cables from the ports on the top of the case to the motherboard's USB header. We slid one 4-pin lead over the top row of pins and attached a fifth lead over the final pin. We attached the second 4-pin lead over the lower row (there's no fifth pin on the lower row).

Next, we installed our drives. The front of the case opens like a book, making it easy to mount the 5.25-inch and 3.5-inch drives. We removed each plastic drive bay cover from the front of the drive by unscrewing two screws from inside the case. You'll need to remove the metal plates from the inner portion of the case, as well, by twisting them back and forth until they break free.



We can't say it enough. If the notch in the bottom of the memory module isn't lined up properly with the slot, it'll take forever to install your memory.

To install our floppy drive, we pulled out the 3.5-inch drive bay cage by pressing the two outer tabs together and pulling the entire cage forward. We used four screws to fasten the floppy drive to the drive cage and inserted the cage until the tabs locked into place. On the DVD burner, we secured two drive rails to each side using four screws. We mounted each rail so the tabs faced the front of the drive and pointed away from the sides of the DVD burner. Once secured, we slid the drive into the proper drive bay until the tabs locked into place. We had to push a little harder than expected to get the DVD burner to lock into place. The rails are designed so that most drives should sit flush with the front of the case. There shouldn't be any need to reposition the rails on the drive to make it sit flush with the front of the case.



Want to use dual-channel memory? Install memory modules in the first and third slot from the processor.

The case includes four hard drive trays that connect. We removed one of the trays by pushing the tabs together and pulling the tray out of the system. Placing the hard drive in the tray so the metal portion was on top, we flipped the entire assembly over and aligned the screw holes on the bottom of the hard drive tray with the holes on the bottom of the hard drive. We then attached the drive to the tray using four of the long screws included with the case. Finally, we slid the tray back into the case until it locked into place.

To make room for our AGP card, we removed the second expansion slot cover from the top by pushing it in from the outside of the system. We then inserted our GeForce FX 5700 video card into the AGP slot and pushed it firmly into place. We used one of the included case screws to secure the card to the case.

Our A865PE includes a separate card to handle CD audio. We removed the cover from the bottom expansion slot and installed the card in the special slot. We also removed the expansion slot cover directly above the card to make room for a dial that controls the CPU fan's rpm. When we're not gaming, we can turn down the fan, making the system significantly quieter. We connected the rpm dial's lead to the connector coming from the heatsink fan.

Using the IDE, SATA, and floppy cables included with the motherboard, we connected the DVD burner, hard drive, and floppy drive to the proper connectors on the motherboard. We then unbundled the power cables and connected the ATX and 12V connectors to the proper power connectors on the motherboard. We used the large 4-pin power connectors to wire the DVD burner, video card, and case fans. We used the smaller 4-pin connector and SATA power connector to power our floppy drive and hard drive respectively. Don't forget to connect the top and side fans to the power supply, as well. Also, make sure you don't forget to connect the CPU fan to the power supply or the system won't boot. Finally, remove the jumper from the small, black wire on the heatsink.

We closed up our case and connected our keyboard, mouse, monitor, network cable, and speakers. We connected the power cable, switched on our power supply, and turned on our system for the first time.

WinXP. Before we install the OS, it's worth checking out the BIOS to make sure everything's in place. After setting the date and clock in the Standard

CMOS Features section, we went into Frequency/Voltage Control to make sure our FSB was set correctly (at 200MHz). We then went into Integrated Peripherals, selected OnChip IDE Device, and made sure On-Chip Serial ATA was set to Auto. In this mode, we won't need third-party drivers to install WinXP.

Before we saved our BIOS settings, we inserted our WinXP CD-ROM and then saved our settings and rebooted the system. The installation went off without much difficulty.

After installing the OS, we went out to Windows Update and installed the latest critical updates to make sure our system was protected. After installing the updates, we installed the motherboard drivers, including the audio and networking driver. We then installed the video driver and rebooted the system so we could set our display to a more flattering resolution.

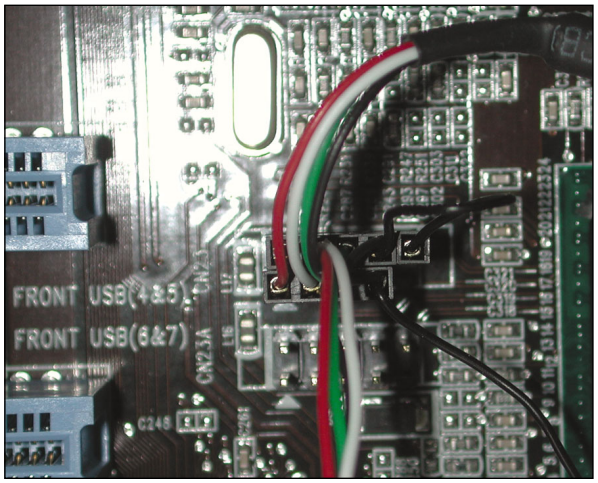
Parts List

Component	Model	Price
Case	RAIDMAX Aluminum Gaming Case 668WPB	$78
Motherboard	Chaintech A865PE	$89
Processor	3.0C GHz P4 (Northwood)	$209
Memory	Kingston 256MB PC3200 DDR SDRAM (x2)	$84
Hard Drive	Western Digital 7200RPM SATA Hard Drive	$69.99
Video Card	AOpen NVIDIA GeForce FX 5700	$123.50
Sound Card	Integrated	
Network Card	Integrated	
DVD Writer	NEC 8X Silver DVD±RW	$59.99
Diskette	NEC 1.44MB Floppy Drive (Black)	$10.99
Monitor*	IBM 17-inch Black CRT	$79.99
Speakers	Cintre RW-6580D	$35.50
Mouse	Logitech MX500 Optical Mouse	$32
Keyboard	Keyboard-2000 Smart 1	$10
Heatsink	Thermaltake P4 Spark 7+	$23.99
OS	Windows XP Home SP1a OEM	$90
Total		**$995.95**

*Monitor not actually purchased, but price fits within our alotted budget

Testing

Overall, this system was one of the easiest builds we encountered, and we had everything up and running in short order. That meant it was time to have some fun, and as luck would have it, we just happened to have Doom 3 on hand (crazy, that). What better way to test a budget gaming system with than the latest title from id?



Connect the USB cables on the top of the case to the USB headers on the motherboard.

Before we transplanted ourselves to a futuristic Martian world, we paused to benchmark our system. At 4517, our overall PCMark04 score was decent but certainly not awe-inspiring. The 4641 CPU score and 4585 Memory score were our strongest scores in the group, with our Graphics score coming in at 3019. Again, if we had a larger budget for a better video card, we could've gotten a much higher score. Our 3273 3DMark03 score also wasn't anything to get too excited about (unless, that is, you take the $1,000 price point into consideration).

So, could our system handle Doom 3? Actually, the game ran fairly well although, as you can probably guess, the detail level and resolution were less than optimal. By default, the game dumped us into an 800 x 600 resolution at Medium Quality. As we found out, however, Doom 3 is fairly conservative when it chooses display settings.

We set the resolution to 640 x 480 and left the settings at Medium Quality and ran our first Doom 3 benchmark. The 42.6fps was more than playable, so we reset the resolution to 800 x 600 and reran the benchmark. Although the score dropped to 35.4fps, the game was still playable. Increasing the resolution to 1,024 x 768 dropped our frame rates to 24.6fps, and increasing the resolution further to 1,600 x 1,200 resulted in an utterly unplayable 11.6fps.

We increased the quality to High Quality and lowered the resolution back to 640 x 480, where we managed a respectable 37.3fps. At 800 x 600 we mustered 29.2fps, and at 1,024 x 768 we managed just 21fps. At 1,600 x 1,200 resolution, we only managed 10.7fps.

We decided to see what our system could do in Ultra Quality. This setting uses massive 500MB texture files, but we managed a decent 31.8fps at 640 x 480. Increasing the resolution quickly brought our system to its knees. At 800 x 600, frame rates sank to 24.9fps, and at 1,024 x 768 they fell to 18.2fps. We didn't have the patience to run the benchmark at 1,600 x 1,200.

Final Remarks

Nonetheless, Doom 3 is playable on our budget gaming system. We reset to the quality to High Quality and set our resolution to 800 x 600 to have some fun. The game ran well, although graphically it was less impressive than it was on our high-end machine (not surprising). If you can ignore some of the jaggies, you'll have some real fun on this system and have enough money for when Half Life 2 is available (whenever that may be). RS

by Chad Denton

Best High-End AMD Gaming Rig For Under $2,500

Cold-Cathode Nirvana, Here We Come

Build #50 Skill Level: 1 2 3 4 5 ***Journeyman***

Although you probably have fond childhood memories of playing Frogger and other blocky, awkward video games, don't think for a moment that you're too old to dive back into the world of video gaming. In fact, many adults have a distinct advantage over most of today's young players: They can afford the high-priced equipment that the latest, greatest games demand.

Of course, you can play most high-end video games, such as Doom 3, Far Cry, and the upcoming Everquest II with lower-end gaming machines, but you'll find yourself turning off many of the visual options that make the games so realistic, and you'll hang your head in shame when a 12-year-old with a souped-up PC stands her tower next to yours at the next LAN party. If you have a midrange system, you'll be able to enjoy some of the latest tricks (especially if your card is pushing the upper limit of the midrange category), but if you want to crank Far Cry to its highest settings, you'll need to invest in the latest equipment.

No matter what you buy, don't expect to have the coolest system at the LAN party for long. Manufacturers replace their best products quickly (new video cards appear several times a year), which means that brand-new video card won't hold the graphics crown for long; in fact, it might cede the title before you finish playing Doom 3. Play fast.

Goal

We put our fears of aging aside and concentrated on building the best AMD processor-based gaming rig money (well, $2,500, a respectable sum) could buy at the moment. Although our budget may struggle to produce a complete, high-end system, it can certainly fund a heavy-hitting box, which is the foundation of a PC system anyway. With that in mind, we scratched the monitor and speakers off our list.

Although the Internet lets gamers meet and play from the comfort of their homes, many choose to lug their boxes to LAN parties, which boast faster networks (thus, no lag, the bane of the Internet gamer) and the chance to meet some of the people you battle in digital combat. To that end, we planned to build a LAN-party-friendly PC that boasts high-end gaming components. And because no one wants to arrive at a party underdressed, we paid more attention than usual to the tower's appearance.

We didn't worry about the system's upgradeability; gamers who want to keep their system up-to-date will regularly buy new components, which means that we don't need to base our purchasing decisions on paths we expect the industry to follow.

Background

We thought about using one of the cases built specifically for LANs, but we decided that we were willing to lug a heavy PC to reap the benefit of having a tall, intimidating system on the BYOC (Bring Your Own Computer) table. The Xaser III V1000D boasts seven 80mm fans, including one attached to a blowhole at the top of the case. You won't always need to have all seven fans blowing at top speed, so the chassis includes a fan control panel that fills one of the case's four external 5.25-inch drive bays.

We matched our blisteringly fast, 940-pin AMD Athlon 64 FX-53 with the feature-laden ASUS SK8V motherboard and then rounded up 1GB of FX-series-only OCZ PC3200 memory (in the form of two 512MB DIMMs so we could take advantage of the board's dual-channel feature). We cooled our CPU with the Thermaltake Pipe 101 CL-P0006 heatsink and a 90mm fan. The Pipe 101 boasts 67 copper fins and several heatpipes and supports AMD Athlon XP, Athlon 64, and Intel P4 motherboards.

Finally, we grabbed the drool-worthy PowerColor ATI X800 video card, which ensured high 3DMark03 scores and game frame rates, and a 250GB, 7200rpm SATA hard drive, which will store all the games and game maps we need. We wanted a 10,000rpm drive, but it would have put us over our budget, and the rules are the rules.

The Build

We spent about 15 minutes (13 more than usual) unpacking the case and

fiddling with its various features. We noticed that the ATX fan power connectors (which also connect to the front fan control panel) are held together by a plastic loom. As a result, all of the connectors sit in one big, airflow-blocking clot in the middle of the case. We made a note to fix that problem when we connected the cables at the end of the build.

The case's side fans attach to a door-like panel that sits just inside the case. The true chassis side panel includes vents that let the fans suck air into the chassis. The fan panel has two brackets that secure the fans and two removable air filters. We like the filters, which prevent at least some dust from cluttering up the system. Our case has an enormous window, so the less dust, the better.

Installing the drives. We snagged a floppy drive, which would let us install the SATA hard drive's drivers during the Windows installation. The Xaser is extremely tall, so we were glad to see that we didn't have to unhook a bunch of fasteners to remove its front panel. Instead, we simply swung the panel open as though it were a door, exposing the two front panel fans (which also have air filters), the 3.5-inch bays, and the 5.25-inch bays. We unscrewed the single thumbscrew that secured the floppy drive sled to the chassis and removed one of the sled's two panels. We also unscrewed the corresponding front panel floppy bay cover and then matched the floppy drive's screw holes to the sled's holes. We screwed the drive into the sled so that the front end extended far enough past the edge of the sled that it would be even with the computer's front panel when we replaced it. (In our case, we used the sled's number 3 hole; it had seven holes for each screw.)

The harness sports plenty of pockets, which means you won't leave your keyboard or mouse behind.

Thermaltake provides dozens of drive runners for optical drives and hard drives, which make installation a breeze. We were surprised to see that, unlike most drive runners, these runners didn't include screw holes. Instead, each runner had two or three pegs that fit into the drive's holes. We worried that the loose fit would let the drives vibrate (which translates to irritating noise) once we powered on the system, but now that we have used the system for several days, we're certain that runners aren't causing any vibration trouble. (In fact, the entire system is ex-tremely quiet, thanks to Thermaltake's chassis de-sign and our Spire foam padding.) We popped out the 5.25-inch bay's metal cover, unscrewed the plas-tic bay cover, and then slid the CD-RW into the bay until the runners snapped into place.

As with the optical drive bays, the hard drive bays supported plastic drive runners. A front panel fan blows air into each drive cage. We could have put the hard drive into the fan controller's sled (which fills the top 5.25-inch bay), but it doesn't have a fan, so we stuck with the drive cage.

Installing the CPU. We pulled the ASUS SK8V out of its box and set it on top of the box's foam padding, which provided a thin buffer between the board and the desk. Next, we grabbed our Athlon 64 FX-53 and then dropped it (gently, of course) into the board's 940-pin socket. We lowered the socket's lever, locking the CPU in place, and then opened our heatsink. The retail versions of AMD processors include aluminum heatsink/fan combos, but OEM versions (such as our FX-53) don't have any documentation or heatsinks. We have no complaints about the Athlon-based heatsink/fans, but we wanted to keep our processor extra cool so it won't have trouble when we take our computer to particularly hot areas, such as LAN parties (think of all of those computers and people in one room).

Oh sure, our harnessed system looks light now, but just wait until you try to lift it.

System Notes	
Outstanding Features	
The PowerColor X800 Pro is screaming fast, even when shouldering the card-crushing Doom 3.	
Weak Link	
No wheels.	
Dimensions (Inches; Tower Only)	20.9h x 8.1w x 20.5d
Weight (lbs; Tower Only)	52.14
Benchmarks	
We ran PCMark04 (version 1.2.0, with Windows Media Player 9) and 3DMark03 (build 340, with DirectX 9.0) at default settings. Our video card had ATI's Catalyst 4.7 driver.	
PCMark04 System	4834
CPU	4500
Memory	5483
Graphics	5697
Hard Drive	4975
3DMark03	10478
Doom 3 (Demo 1)	
1,024 x 768 (High Quality)	56.6fps
1,024 x 768 (Ultra Quality)	51.7fps
1,600 x 1,200 (High Quality)	34.1fps
1,600 x 1,200 (Ultra Quality)	31.3fps

Most heatsinks require a retention frame that surrounds the CPU socket, but our Pipe101 heatsink required only the motherboard's backplate. We attached the backplate to the board and used the heatsink's long screws to secure our 90mm fan to the heatsink. We could have installed a standard 80mm fan, but where's the fun in that? Next, we slid the I-bar through the heatsink's center aisle, which separated the 67 copper fins. We turned the bent I-bar so that each end pointed upwards and then rested the heatsink on its side to avoid dirtying the portion of the base that would later contact the CPU.

Next, we opened the heatsink's tube of thermal compound and spread it over the CPU, following the instructions. We placed the heatsink on the CPU so that the grooved edge covered the raised portion of the CPU socket. Once we had the heatsink where we wanted it, we slipped rubber washers onto two screws and then twisted them through the I-bar's holes and into the backplate. We jumped back and forth between the screws as we twisted them so that we wouldn't apply too much pressure to either side of the heatsink. Finally, we plugged the fan's power cable into the motherboard's CPU fan connector.

Installing the motherboard. Before we tossed our SK8V into the spacious chassis, we installed 1GB of super-speedy, enhanced OCZ PC3200 in the board's dual-channel memory slots. Once we snapped each slot's clips into place, we turned to our chassis. Our case's bag of screws included typical standoffs, of which we screwed nine into the mobo panel. We also attached the motherboard's I/O port shield to the back of the case. Next, we pressed the dual-fan panel's two tabs and swung it out of the way. We carefully lowered the motherboard into the case and used nine screws to secure it to the standoffs.

Once we installed the motherboard, we pulled the Radeon X800 video card and its DVI adapter out of its box. Unlike most cases, which let users secure PCI bay covers with screws, the Xaser III has a toolless bay cover design. To install the video card, we flipped open the gray plastic latch over the appropriate cover, lifted the latch and pushed the card into the AGP slot until the AGP socket's clip locked, and then lowered and closed the bay's latch. Whew.

Installing the extras. We didn't have any PCI cards (we used the mobo's integrated sound instead of an add-on card), so we opened our package of Spire foam padding, which reduces drive noise. We cut several pieces and placed them inside the case. If the case's side panel didn't have a window, we would have covered it with padding, but the window prevented us from putting any on the panel at all.

Next, we connected the myriad power and data cables that cluttered our system. We tucked the wad of fan connectors out of the way, connected the fan controller to a standard ATX connector, and used electrical tape to hang the temperature sensor near the top of the case.

Watch Out

As we discovered when we tried to lift our huge gaming box, bigger isn't always better. When we first started shopping for our rig's components, we hatched what should have been a simple plan: Build a large but portable system that would intimidate LAN party opponents. We weren't certain that other players would associate a massive PC with massive gaming skills, but we figured that the extra-large case would at least annoy the player sitting next to us. Hey, an edge is an edge.

We liked Thermaltake's detailed cases, but we scoffed at the aluminum LANMOTO. Instead, we chose the Xaser III Super Tower, which boasts a slight height advantage and an ultra-sturdy frame. Unfortunately, it also has plenty of weight: 34 pounds (without the included power supply) to the LANMOTO's 11 pounds. By the time we threw all of our components into the case, our PC, sans keyboard and mouse, weighed a back-breaking (for us at any rate) 52 pounds.

The lesson we learned: count the pounds when you build your LAN party system. You won't have the biggest PC on the block if you travel light, but you'll arrive. We, on the other hand, will stick to Internet games until we build a smaller rig. ▲

Parts List

Component	Model	Price
Case	Thermaltake Xaser III Super Tower V1000D	$150
Motherboard	ASUS SK8V*	$182
Processor	AMD Athlon 64 FX-53 (940-pin)*	$799
Memory	1GB OCZ PC3200 ECC Registered Dual Channel DDR (512MBx2) OCZ4001024ELERDC-K	$300
Hard Drive	250GB Maxtor 7Y250M0	$201
Video Card	256MB PowerColor ATI x800 PRO R42-PVD3*	$479
Optical Drive	Lite-On CD-RW/DVD-ROM SOHC-5232K	$48
Floppy Drive	Generic*	$8
Soundcard	Integrated w/Mobo	$0
Mouse	Logitech MX510 **	$48
Keyboard	Logtech Black Keyboard**	$11
Operating System	Windows XP Home	$90
PSU	420W Silent PurePower Integrated w/Chassis	$0
Heatsink	Thermaltake Pipe 101 CL-P0006	$56
Heatsink Fan	Thermaltake 90mm A2017**	$12
Noise Control	Spire SP-SoundPad01	$10
IDE Cable	Antec Round IDE 77226**	$11
Floppy Cable	Generic Round**	$2
Lighting	Logisys Red Cold Cathode CLK12RD (x4)	$32
Harness	Thermaltake Xaser Bag A1700 (Big Tower)	$20
Wheelbarrow	True Temper 6 Cu. Ft. Steel ***	$40
Total		**$2,499**

* Equipment previously purchased.
** Used similar in-house items.
*** Don't cheap out here. One loose bolt and your 52-pound rig hits the pavement.

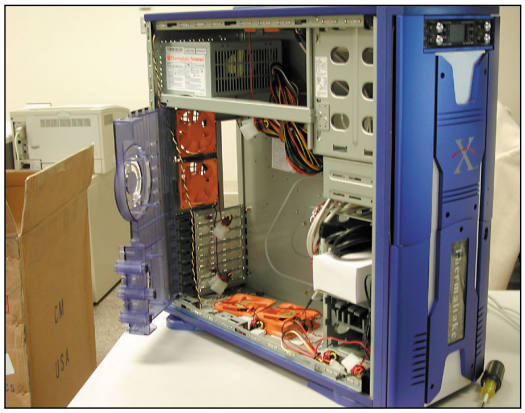
Before we replaced the panel, we remembered our two cold-cathode lights. We used the included stickers to attach one of the lights to the motherboard panel and then attached the second light to the floor. We plugged both lights into an included 12V dual-light inverter. Unfortunately, the lights just didn't create the bright-red effect we were looking for. We installed two more cold cathodes near the top of the case (we were careful not to attach them to the side panels), which did the trick.

Bling Bling

If your case has a window and you're itching to light up the system's guts, grab a few cold-cathode lights. We like cold-cathode tubes because they don't emit heat, which means you can load up your computer without worrying about melting components or starting fires. Cold-cathode lights are relatively bright, but expect to use more than one in your case. Our first two red lights cast a soft glow over the system's components, so we installed two more to create a stronger glow that bathed both the peripherals and ourselves in red. Each cold-cathode package included an inverter that supported two tubes, so we used only two of our four inverters. We used 12-inch tubes; retailers offer a variety of sizes. If you want to wrap lights around an object, take a look at EL (Electro-Luminescent) lights, which are longer and much more flexible. ▲

Four red, 12-inch cold-cathode lights make for a bright system.

Finally, we double-checked the CPU fan power connector and then powered on the system. It sprang to life right away, so we entered the BIOS to make sure that the memory's ECC feature wasn't enabled (we didn't want to slow down our speedster) and then rebooted and loaded Windows. We pressed F6 shortly after Windows XP began its installation and then loaded the SATA drivers when prompted. (We downloaded the VIA RAID version 2.10 driver from usa.asus.com and then copied it onto a floppy disk.) WinXP finished the installation without a hitch.



The Xaser III Super Tower boasts seven fans, not including the PSU's fans.

Testing

We expected great things from our champion AMD gaming PC, so we were disappointed when it spit out a 4834 PCMark04 System score, only 132 points higher than our high-end AMD system's best. Both systems had the same $2,500 budget, but we put the money we saved (by not buying a monitor and speakers) into the gaming system's video card. Our system is a gaming rig, after all, not an office machine, so we unleashed it in a more suitable arena: 3DMark03. After paying $479 for our PowerColor ATI X800, we fully expected it to blow away the $260 ASUS GeForce FX V9950—and it did. Our massive blue box tore through Futuremark's latest synthetic benchmark, posting a whopping 10478 3DMarks.

Of course, benchmarks can only approximate the user's experience, so we took our rig for a real-world spin. We listened to music, watched DVDs, and then gave it the ultimate gaming test: We played Doom 3. Hours of Doom 3. Sure, the card produced stunning graphics right away, but could it keep up the pace for hours of monster slaughtering? We had to find out for you, dear reader. We're happy to report that the X800 likes Doom 3 as much as we do.

To give you a feel for the card's smooth performance, we ran the Timedemo benchmark. If you have Doom 3, start it and then press CTRL+ALT+~. When the console appears, type **timedemo demo1**. At the popular 1,024 x 768 resolution, on High Quality, our system produced a 56.6fps frame rate. When we bumped the game to 1,600 x 1,200, the frame rate dropped only to 34.1fps.

Also, we really liked the PC's sound when we gamed, watched movies, and listened to music. The integrated sound won't top a high-end Creative Labs add-on card, but it provided crisp audio nonetheless, whether we used speakers or headphones.

Final Remarks

In retrospect, we should have gone with Thermaltake's 11-pound LANMOTO chassis. Our high-end gaming rig is a serious heavyweight, and we're not just talking performance. At 52 pounds, this 20.1-inch tall system shouldn't leave the floor, ever. Thermaltake's XaserBag (Big Tower size) fit our system like a glove, but this rig needs wheels more than a shoulder strap. Thanks to our poor chassis selection, we missed the LAN-party-friendly portion of our goal.

However, our rig came through for the goal that matters most: gaming power. The system has decent sound and cutting-edge graphics capabilities, plenty of storage, and a fan controller/temp monitor that lets you control all of the system's many case fans. And if you do tow, er . . . *take* it to a LAN party, friends and foes alike will appreciate the system's bling bling. RS

by Joshua Gulick

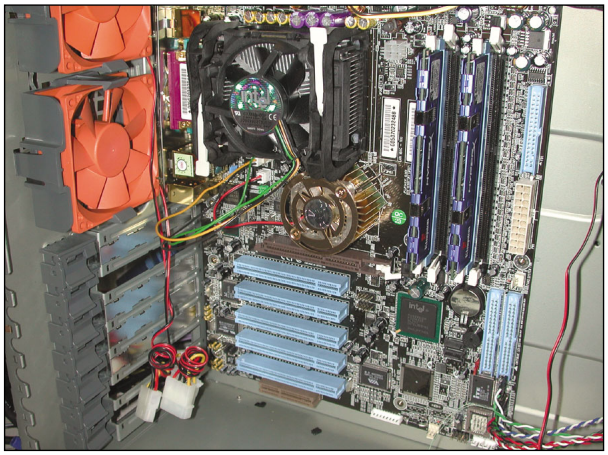
Best High-End Intel Gaming System Under $2,500

Vanquish Your Enemies With This High-End Gaming System

Build #51 Skill Level: 1 2 3 4 5 *Master*

A mad scientist has opened up a portal to hell on Mars, and you're the only Marine that can stop the plague of demons from reaching Earth. Or, perhaps you find yourself washed ashore on a deserted island with strange creatures and mercenaries who want you dead. Regardless of your situation, there are three things you're going to need: a pixel-pushing graphics card, a data-hungry processor, and high-end components that will get you through the night.

We combined one of Intel's best gaming processors with NVIDIA's latest graphics card, added a SATA RAID 0 array, 1GB of memory, and Intel's high-end 875P chipset. The result is a power-hungry behemoth that's a perfect machine for anyone who wants to hunt demons in Doom 3 or slink around a tropical island in Far Cry.



Our 3.2GHz Pentium 4 Extreme Edition and 1GB of DDR SDRAM ought to make for a powerful system when combined with our NVIDIA GeForce 6800GT video card.

Goal

Our goal was to build the absolute best gaming system we could for the allotted $2,500. Granted, $2,500 is not a lot for a high-end entertainment system, so we cheated a bit and excluded a monitor and speaker system from our budget. We already had plenty of those components lying around, and we figured most power users probably would, too.

Background

Once again, the video card and processor are the two most important components in any gaming system, and it's here we planned to spend the majority of our budget. Intel's 3.2GHz Pentium 4 Extreme Edition's 2MB of L3 Cache helps improve gaming performance. Between the time we bought the processor and the time we went to press, Intel discontinued the 3.2GHz EE. The processor, however, isn't going to disappear anytime soon. The final production date isn't until November and the final ship date isn't until February of 2005, so you should be able to find this chip if you act quickly.

We really wanted an NVIDIA GeForce 6800 Ultra, but it would've been easier to find a grammatically correct sentence in a motherboard manual than find an Ultra at retail. We settled for a $449 eVGA NVIDIA GeForce 6800GT. Our $449 included a free edition of Far Cry. Between the video card and the processor, we had spent nearly 50% of our allotted budget, but that meant we still had roughly $1,250 to spend on the rest of the system.

If we're going to spend that much money on a processor and video card, we wanted to make sure our motherboard and memory didn't slow things down. We settled on Chaintech's 9CJS Zenith motherboard. The 9CJS Zenith uses Intel's high-end 875P processor on the northbridge and an Intel ICH5R on the southbridge. The ICH5R includes support for SATA RAID 0 or 1. The motherboard also includes integrated audio and Ethernet, plus a handy C-BOX unit that mounts in a 5.25-inch drive bay and includes USB, FireWire, and audio support, along with card reader slots for CompactFlash, MicroDrive, MMC, and SD.

We installed two 512MB sticks of PC3200 DDR SDRAM. The memory will let us take advantage of the motherboard's dual-channel memory support, as well as Intel's PAT (Performance Acceleration Technology). PAT uses more aggressive memory timings to decrease latency when used with PC3200 DDR SDRAM. By most accounts, the performance increase isn't always worth the extra price, but we'll take what we can get. Besides, we like some of the other high-end features on this board.

We used two Western Digital 7,200rpm SATA hard drives that we'll combine into a single 160GB RAID 0 array. We spent $93 on a Pioneer DVD±RW drive and $10.99 on a black NEC floppy drive. We'll need the floppy drive to install Windows XP on our SATA RAID array.

Of course, we'll need a high-end case to house all our components. Thermaltake's Xaser Series III V1000A comes with seven fans (two in the front, two in the rear, two on the side, and one on the top), requires very few tools, and has a nice "Hardcano" with four fan speed dials and a temperature readout. The case costs $145, but considering it

includes a 420W Thermaltake power supply, the price isn't all that bad.

Finally, we bought an Ideazon Zboard keyboard and Razor Viper optical gaming mouse. Ideazon makes Zboard inserts for some games (Civ III, for instance), and the Viper mouse includes software that lets you quickly adjust sensitivity and other properties.

The Build

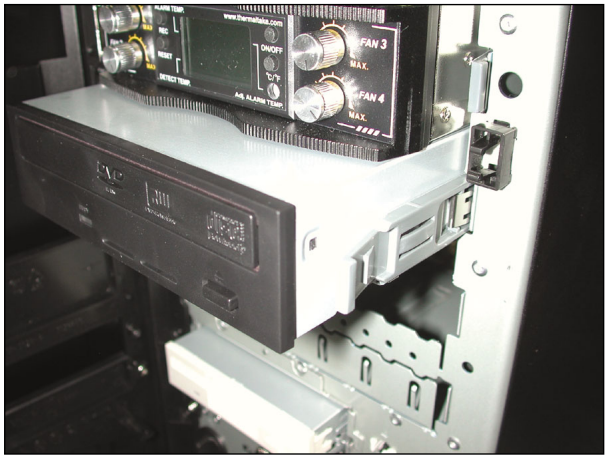
The first thing we thought when removing our Thermaltake case from the box was "hernia!" The case is very solid and very heavy. Our case included significantly fewer screws than other cases, and we were a little worried that we wouldn't have enough screws to complete the installation. We soon learned most components don't require any screws to install.

To remove the left side panel from the case, we removed the keys tied to the back of the system and unlocked the front lock. Once unlocked, we were able to remove the thumbscrews from the left side panel. Rather than mount the side fans directly to the side panel (a design the requires you to disconnect and reconnect the side fans every time you need to remove the side panel), the Xaser Series III case mounts its fans to a large plastic mount directly inside the side panel. We pressed in the tabs near the front of the system and were able to swing open the side fans. We then pressed up on the upper-rear tab to completely remove the side fans.

We pressed the rear I/O plate included with our motherboard into position on the back of the case and then set the case on its side, lowered the motherboard into position, and noted the locations where we needed to install standoffs. After removing the motherboard, we screwed the standoffs into the proper position.

Before we installed the motherboard into the case, we decided to install the processor, heatsink, and memory. We dropped our 3.2GHz Extreme Edition processor into the ZIF socket and placed a small amount of thermal paste on the processor's heatspreader. We pushed straight down on the heatsink guard until it locked into place with the heatsink guard on the motherboard and then flipped both levers to secure the heatsink. We connected the CPU fan lead to the header directly below the processor socket on the motherboard and then installed both sticks of RAM to the two blue memory slots on the motherboard.

Our next step was to install the motherboard in the case by using the included screws to secure it to the standoffs we installed earlier. Once secure, we wired the case leads to the front panel headers on the motherboard. Consult the motherboard documentation to determine what pins you need to attach each lead to. Remember, you should place the colored wire over the positive pin and the black wire over the negative (or ground [GRD]) pin.



With the drive rails attached, simply insert the DVD burner until it clicks into place.

We already had our processor installed, so it was time to install our second major component: our video card. We flipped up the tab next to the top expansion-slot cover and pulled the tab out toward the side of the system. We pushed the metal guard out from the back of the system and inserted the AGP card into the slot. To secure the card, we pushed the plastic tab in and flipped it down. We repeated the procedure to install the accompanying audio card for our motherboard into the bottom expansion slot.

Before we installed the drives, we needed to remove the plastic drive bay covers from the front of the system. The entire front panel swings open like a book, giving you easy access to the front drive bays. We used a screwdriver to remove the top two 5.25-inch drive bay covers and the top 3.5-inch drive bay cover. We then rotated the 5.25-inch metal guards on the inside of the case until they broke free.

To install the floppy drive, we removed the screw securing the 3.5-inch drive bay cage and pushed the cage out the front of the system. We removed the top internal 3.5-inch drive bay guard and inserted the floppy drive. We positioned the drive so the rear screw hole was aligned with the number 5 hole on the drive cage and secured the floppy drive using four screws. We reinserted the drive bay cage and secured it to the front of the case using the screw we removed earlier.

Installing the DVD burner was quick and easy. We inserted the plastic pegs on each drive rail into the screw holes on the side of the drive (making sure the tabs faced the front of the drive). We then pushed the drive into the drive bay until the rails locked into place.

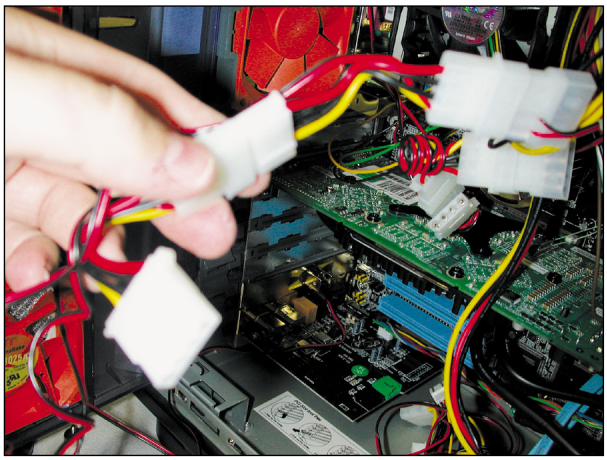
To install the C-BOX, we connected the USB, FireWire, and DigiDoc display cables to the corresponding headers on the back of the C-BOX and removed the rubber band from the power connector. We mounted the C-BOX just as we mounted the DVD burner above and then connected the USB, FireWire, and DigiDoc leads to the proper headers on the motherboard. See the motherboard manual for the exact location of each header. Note that we didn't install the audio cable for the front audio connections. This is because connecting this lead disables the rear audio output, which isn't something we want to do in this case.

To mount the hard drives, use the smaller hard drive rails. Place the plastic tabs into the screw holes on the side of the drive and make sure the bottom tab rests over the bottom of the drive (the side with all the circuitry). Push the drive

into one of the internal 3.5-inch drive bays until it locks into place.

Next, we used the included floppy drive, IDE, and SATA cables to connect our floppy drive, DVD burner, and hard drives to the motherboard. We placed the side fans into the bottom post near the back of the system and pushed the top post until it locked into place. All case fans have male and female connectors, so we wired each set of fans together. Four of the ATX power leads from the Hardcano are labeled Fan 1, Fan 2, Fan 3, and Fan 4. We connected Fan 1 to the rear case fans, Fan 2 to the side case fans, Fan 3 to the front case fans, and Fan 4 to the top case fan. Connect the remaining two leads to the power supply. We can adjust the speed of each set of fans by using the proper dial on the front of the case.

Next, we connected the ATX power and 12V connectors to the motherboard. We connected the large 4-pin ATX power connectors to the C-BOX, DVD burner, and video card, the smaller 4-pin power connector to the floppy drive, and the SATA power connectors to the hard drives (alternately, you can use the 4-pin power connectors to power your hard drive, but don't use both the SATA and 4-pin connectors at the same time). Once we finished, we closed the side fans and secured the side panel. We plugged in our keyboard, mouse, Ethernet, speakers, monitor (both borrowed from our basic high-end Intel build), and power cord, and prepared to install Windows XP.



Connect both sets of front, rear, and side fans together, and then connect each set to the power leads from the temperature control center.

System Notes	
Operating System	Windows XP Home
Processor	3.2GHz Pentium 4 Extreme Edition
RAM	1GB PC3200 DDR SDRAM
Bus Speed	800MHz
Hard Drive	160GB SATA RAID 0
Optical Drive	DVD±RW
Connectivity	10/100 Ethernet, Gigabit Ethernet
Video Card	NVIDIA GeForce 6800GT
Video RAM	256MB
Sound Card/Speakers	7.1-Channel Surround Sound
Chassis Size (inches)	20.9 x 8.1 x 20.5
Weight (lbs)	51.42
Benchmarks	
3DMark03	11314
PCMark04	5149
CPU Score	5018
Memory Score	5365
Graphics Score	7311
HDD Score	5986
Doom 3	
Medium Quality	
640 x 480	63.8fps
800 x 600	56.7fps
1,024 x 768	54.1fps
1,600 x 1,200	49.4fps
High Quality	
640 x 480	46.1fps
800 x 600	45.0fps
1,024 x 768	44.2fps
1,600 x 1,200	41.6fps
Ultra Quality	
640 x 480	43.6fps
800 x 600	44.1fps
1,024 x 768	42.6fps
1,600 x 1,200	39.2fps

WinXP. Before we install WinXP, we needed to create a driver disk that contains the SATA RAID drivers. We used another computer to copy the files in the Intel\Iaadrv\Bootdrive directory on the Intel Chipset Drivers CD-ROM to a blank floppy disk.

With the driver disk in hand, we turned on our new gaming system for the first time and pressed DELETE to enter the BIOS setup utility. We visited the Frequency Voltage Control section and made sure the FSB was set to 200MHz. We then returned to the main menu and selected Integrated Peripherals and then OnChip IDE Device. We set SATA Mode to RAID, inserted our WinXP installation CD-ROM, saved our settings, and rebooted the system.

When prompted by the system, we pressed CTRL-I to configure our RAID array. We selected Create RAID Volume from the main menu and followed the prompts using the default values.

Eventually, the system loaded the WinXP installer. Shortly after you see the initial blue screen, you'll see a prompt along the bottom asking you to press F6 to install a third-party driver. We pressed F6 and waited for a few seconds while WinXP copied some general drivers. Eventually, WinXP prompted us to press the *S* key to install third-party drivers. After pressing *S*, we were asked to insert the floppy disk we created earlier and press ENTER. We selected the Intel 82801 SATA RAID Controller For Windows XP & 2000 and pressed ENTER. We pressed ENTER a second time to continue with the installation. The rest of the process continued as normal.

Once Windows was up and running, we installed updates from Windows Updates and installed drivers for our motherboard. Next, we installed our display drivers for our video card before finally installing our benchmark software along with Doom 3 and Far Cry.

Testing

At 5149, our PCMark04 Overall score wasn't overly impressive and we were actually a little disappointed by our 5018 CPU score. The 5365 Memory score was also disappointing compared to past Memory scores we've seen on this motherboard. The

Behold Doom 3 in High Quality at 1,024 x 768.

7311 Graphics score, however, was our first indication of an impressive 3DMark03 score to come. Our 5986 HDD score came in just under the 6000 mark.

The 11314 3DMark03 was almost shocking and due mainly to our GeForce 6800GT. In our last PC Modder issue, we overclocked a 3.4GHz Extreme Edition and NVIDIA GeForce FX 5950 Ultra on this same motherboard and managed just 6884 in 3DMark03 with the processor running at 3.77GHz.

We installed Far Cry to see how well the system could handle a graphics intensive game. Far Cry detected our system as a Very High Performance system and adjusted the settings accordingly. Gameplay looked great and handled well. The real question on our minds was how well the system could play Doom 3.

The answer—at Medium Quality and a resolution of 640 x 480—we managed 63.8fps. We should note that during gameplay, Doom 3 will not deliver more than 60fps. Of course, that doesn't matter much because few people with this system will want to settle for Medium Quality at 640 x 480. Increasing the resolution to 800 x 600 dropped us to 56.7fps. At 1,024 x 768, we hit 54.1fps. At the maximum 1,600 x 1,200 resolution, we managed 49.4fps.

Moving to High Quality setting and lowering our resolution to 640 x 480, our system delivered 46.1fps. Frame rates dropped slightly as we increased the resolution. At 800 x 600 and 1,024 x 768 the system managed a 45.0fps and 44.2fps respectively. At 1,600 x 1,200 frame rates fell to a still playable 41.6fps.

Although we only have about half the memory the large texture settings used in Ultra Quality demand, we went ahead and tested our system at the highest quality level. At 640 x 480, frame rates were still a responsive 43.6fps. Frame rates actually picked up a bit at 800 x 600 to 44.1fps but fell to 42.6fps at 1,024 x 768. At 1,600 x 1,200, the system was still clicking at 39.2fps. We played the game at this setting and found it very playable.

Activating antialiasing dropped frame rates pretty quickly. On High Quality at 1,024 x 768, 2X antialiasing dropped frame rates from 44.2fps to 43.2fps. At 4X frame rates dropped to 41.2fps. At 8X, we saw a drastic reduction in frame rates to 23.3fps. Finally, at 16X the game was unplayable at just 16.0fps.

Scores weren't dramatically different in Ultra Quality although we did actually manage higher scores at 2X and 4X in Ultra Quality than we did at High Quality. Scores were 48.6fps, 43.8fps, 22.5fps, and 15.0fps at 2X, 4X, 8X, and 16X, respectively.

Final Remarks

We were extremely impressed with the system scores, loved the fact that our video card came with a decent game, and really enjoyed our Xaser Series III case. That said, the case is heavy, so you're not going to want to take this system to your next LAN party. The Ideazon Zboard sounds like a better idea than it is, but the Viper proved to be a comfortable gaming mouse. We were very happy with our video card performance, but our system's graphics cards may not be upgradeable for very long. Our system, for instance, is locked into AGP. We'll need to replace the motherboard if we want to play with the PCI Express video cards due out soon. Now if only this system could help us find Bravo Team. RS

by Chad Denton

Parts List

Component	Model	Price
Case	Thermaltake Xaser Series III V1000A	$145
Motherboard	Chaintech 9CJS Zenith 875P	$169
Processor	Intel 3.2GHz Pentium 4 Extreme Edition	$899
Memory	Kingston HyperX 512MB (x2)	$264
Hard Drive	Western Digital 80GB 7,200rpm (x2)	$146
Video Card	eVGA NVIDIA GeForce 6800GT	$448.95
Sound Card	Integrated	
Network Card	Integrated	
DVD Writer	Pioneer Black 8X DVD±RW	$93
Diskette	NEC 1.44MB Floppy Drive (Black)	$10.99
Mouse	Razor Viper	$45
Keyboard	Ideazone Zboard	$19
OS	Windows XP Home SP1a OEM	$90
Total		**$2,329.94**
Extra Components		
Monitor	ViewSonic Perfect Flat 21-Inch CRT	$429
Speakers	Creative Inspire T7700 7.1	$115
Total		**$2,873.94**

Most Versatile Watercooled Overclocking System Under $1,500

Your New PC Is Thirsty

Build #52	Skill Level with kit:	1	2	3	4	5	Master
	Skill Level without kit:	1	2	3	4	5	Grand Master

If you have champagne tastes when it comes to overclocking but you're on a beer budget, the answer may be watercooling your PC. Many liquids transfer heat better than air, so watercooling will probably let you overclock your components to higher levels.

In a typical watercooling system, a pump circulates water from a reservoir through special copper or aluminum heatsinks called waterblocks. Flexible hoses carry the heated coolant through a radiator, where a fan removes heat from the water and expels it from the case. Without a CPU or graphics card fan, a watercooled PC can be pretty quiet.

Watercooling can't chill your chips below room temperature, in contrast to the dizzyingly cold -50 degrees Celsius of a phase-change cooler such as the Nventiv Mach II. On the other hand, watercooling costs only a quarter as much or less, and it's not limited to cooling only your CPU.

The most obvious drawback is the possibility of leakage. Not only will water immediately short out any live electronics it touches, but it could also endanger you if you don't unplug the computer before you try to mop up. The other downside is that you'll need to flush the system and change the water and additives twice a year or so.

Some folks enjoy hunting up all the parts, hoses, and screws for a custom watercooling system. We don't, so we bought this awesome kit from Asetek.

Goal

For $1,500, we wanted the most versatile, watercooled overclocking system we could build. Overclocking demands stability, so we took the high road of quality with names such as Asetek, Intel, ASUS, and Antec.

We didn't have room for the usual step-by-step PC building instructions, so thumb through the rest of this issue for additional guidance.

Background

The $279 CPU/VGA/chipset watercooling kit from Asetek was pricy, but it appealed to us because of its high quality and completeness. If this is your first experience with watercooling, it's best to start off with a kit. It avoids the hassle of mixing and matching parts from online shops and hardware stores.

We chose a tower case, so any leaks would mostly fall into the bottom of the case and hopefully only ravage our video card on the way down. We also wanted aluminum construction for extra passive cooling, so we bought a Lian-Li PC-61 case. Besides having five fans, it was of outstanding quality, top to bottom.

Typically, overclockers want faster gaming and video editing, not to mention speedier media encoding. Hence, we made some tough tradeoffs to get a decent video card. This meant settling for an 80GB hard drive and a CD-RW to get a sub-$185 Radeon 9800 Pro. Try a $175 GeForce FX 5900XT if you're more into Shader 3.0 or OpenGL games such as Doom 3.

By definition, PC4400 DDR is overclocking RAM. It's specified to run at up to 550MHz, faster than any CPU's stock FSB. OCZ's Gold Edition PC4400 impressed us in our *PC Modder* issue tests, so we kept it around. OCZ recommended the notably overclockable i875P-based ASUS P4C800-E Deluxe as one of the few motherboards that fully supported this RAM.

On this budget, a P4EE or Athlon 64 FX-53 wasn't in the cards. Overclocking is about making low-buck parts perform like

expensive ones, so we didn't feel too badly about buying a cheap CPU with a reputation for enormous O/C potential: the 2.4GHz P4 model C.

The Build

We started by figuring out the locations of the watercooling parts before installing anything permanently in the case. We planned to cut the hoses to the proper lengths later on. The reservoir fit nicely in the 5.25-inch drive bays without touching the CD-RW in the top rack. We mounted the tank with some adhesive-backed Velcro (not included in the kit). The reservoir would be the highest point in the system, letting it trap any bubbles that could block water flow and cause hot spots.

We attached the 120mm fan to the radiator as instructed, label side out to pull air through the fins. We quickly found that our radiator assembly was just a little too big to fit anywhere convenient inside the case. We considered mounting it to vent out of the front, out of a new hole in the side panel, out of a series of expansion slot cutouts, out of the top blowhole, and even into the lowest drive cage from the middle of the case floor. All of our options involved a) reversing airflow to a less efficient top-to-bottom scheme, b) losing more drive bays or slots than we wanted to, and/or c) cutting, drilling, and bending our beautiful case. We're not shy about the latest route, but time was short. In the end, we newbishly routed the radiator assembly outside the case entirely.

Next, we prepared the motherboard for installation on Lian-Li's mounting clips. We pushed these up through the bottom of the motherboard tray. We had to remove the black plastic heatsink bracket surrounding the CPU socket so that we could mount the processor waterblock later. In its place, we added the four cylindrical metal standoffs included in the Asetek kit, each about 1.5 inches long. We fed a small screw and plastic washer up through each of the holes from the bottom of the motherboard and into each standoff until it looked like the CPU socket was in a four-post bed. Next, we mounted the ASUS I/O shield and motherboard in the case, and installed the Pentium 4 and Antec power supply.

Our plan was to assemble the watercooling system, mount the waterblocks, and cut all hoses to fit. Next, we would test the system for leaks without powering up the motherboard, CPU, or anything else. If all went well—don't count on that the first time—we would affix the blocks and connect power to the rest of the PC.

CPU waterblock. The CPU waterblock had three hose fittings, making it easy to spot. For now, we left the protective tape on the waterblock and left both the processor die and waterblock dry, or free of thermal grease. This would let us make a test run with the watercooling system in place and pumping water, yet without the rest of the computer turned on. If no leaks show themselves after a few hours, we'll continue to the following steps to add thermal compound and mount the waterblock more permanently.

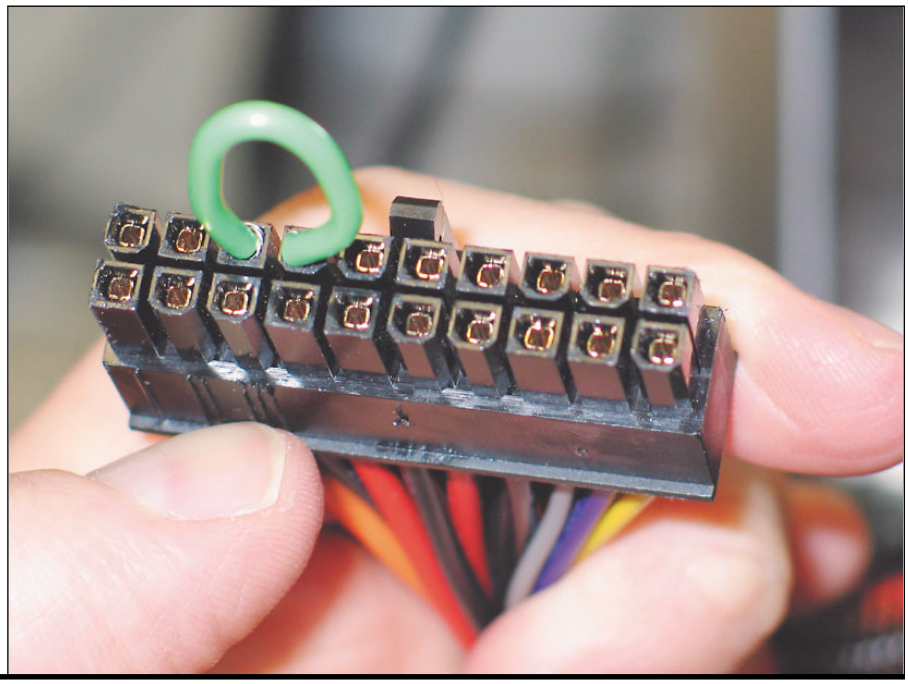
The block slid down the four standoffs to touch the Pentium, and we followed it with the kit's four springs, plastic washers, and thumbscrews. After the thumbscrews touched the tops of the springs, we turned each screw one revolution, moving from screw to screw until each had been turned five times.

After our test session, we removed the waterblock once again. Using the edge of a credit card, we added a thin, even coat of thermal grease included in the kit to the processor's metal heatspreader. Next, we peeled off the protective tape on the underside of the CPU waterblock. We rubbed some thermal goop into the waterblock with a lint-free cloth to fill its tiny pores and voids and then remounted it on the processor.

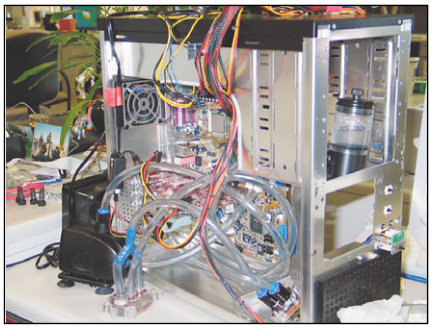
VGA waterblock. Before we could add the VGA waterblock—the one with the two side water couplings—to our video card, we had to detach the stock ATI fan and heatsink. We lay the card on a mousepad first. We tried to depress its spring-loaded retaining pins with our fingers, but a bloodletting jab under the fingernail by a heatsink tine quashed that motion. We cried all the way home and then came back with our big brother—a pair of needle-nosed pliers.

The spring retainers still gave us trouble, so we flipped the card over and pinched the pins' barbed ends with the pliers. They popped right out. The Radeon's wire traces and components are unprotected around the pins, so take care not to scratch any-

This feels so naughty. We're tricking the power supply with a shunt wire so that we can test the watercooling system for leaks without turning on the PC. Make darned sure you're shorting the right pins: 13 (black) and 14 (green).



The easy way to slip hoses on the CPU waterblock outlets' Y-adapter is to soak their tips in hot water first.



Testing for leaks is a lot more fun when you can't find any. How are we gonna fit all this in the case?

Overclocking from 2.4GHz to 3.4GHz isn't too shabby.

thing. We removed the heatsink and its fan cable and then cleaned off the Radeon VPU with a cloth and a little acetone.

As we did with the CPU above, we left out the thermal goop until we could test for leaks. To mount the VGA waterblock, we oriented it so that the couplings faced toward the 4-pin Molex power connector. Otherwise, it would have been a pain to route the water hoses later. We set the waterblock on the exposed Radeon VPU.

The attaching hardware for each block was in a separate plastic bag; the VGA block's bag contained two long bolts. We ran a long bolt and washer through each of the waterblock's mounting slots and the heatsink holes in the Radeon card. On the back of the card, we secured each bolt with a washer, spring, another washer, and a white, plastic finger nut. We tightened each nut one turn at a time until the waterblock was snug, but we didn't overtighten.

Later, before we started the computer for the first time, we peeled off the waterblock's tape and applied a thin layer of thermal paste to the VPU. We rubbed some paste into the waterblock's underside with a cloth until it was dull and dry and then reattached the block to the graphics card.

Chipset waterblock. We removed the passive heatsink on the motherboard's MCH (memory controller hub), or northbridge, by pressing down the end of each clip and moving it toward the sink. Some thermal putty kept the heatsink in place. We didn't want to hurt the chip by a straight pull upward, so we twisted the sink from side to side a few times until it popped off. We carefully cleaned the rest of the putty off the northbridge with a few dabs of acetone on a cloth. If we can locate some double-sided thermal tape later, we might stick that heatsink on the southbridge for laughs.

We could have asked for a better mounting method from Asetek than nylon ties through the waterblock and the board's sink clip loops, but that's all we got. Blame Intel. AMD- and VIA-style northbridge waterblocks employ a more sensible bolt-and-spring system, such as the VGA block. For our test run, we left the tape on the waterblock (the one with two hose fittings pointed straight up) and then set the block on the northbridge without any thermal compound. Rather than waste Asetek's single-use nylon ties on the testing phase, we used a couple of twisties.

After our test below, we removed the waterblock once more and stripped off its white tape. We applied thermal compound to the chip and waterblock as outlined in the CPU and VGA waterblock sections above and then replaced the block on the northbridge. We ran the included nylon ties through opposite corners of the block and the motherboard loops and then tightened each a little at a time until the block was as tight as we could manage.

Watch Out

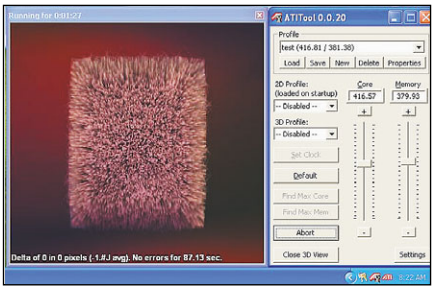
When your watercooled system is working correctly, its pump will be nice and quiet. If the pump suddenly gets annoyingly loud, pull the PC's power cord right away. It means that air has entered the system. There's only one way for that to happen: a leak. ▲

Hoses. Coolant will flow from the reservoir to the pump's side inlet, out the pump's top outlet to the radiator, and then on to the middle inlet of the CPU block. From the two outer outlets of the CPU, the water will meet in a plastic Y-adapter and then go to the video card and motherboard northbridge waterblocks. The northbridge block will flow back to the reservoir.

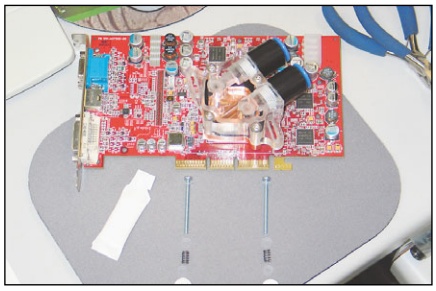
Cut your hoses very straight across with a sharp razor or knife. Slanted or ragged edges will leak with the Asetek blocks' type of fittings. Not only will you need enough hose to reach each waterblock, the pump, the reservoir, and the radiator, you'll need to make each hose's path a gentle curve. If a hose is too short, it will bend and kink. That will shut down water flow and let your chips overheat. Keep in mind that you may need to move some components later for maintenance, so a little slack in the hoses is a good thing as long as it doesn't cause kinks or bind on other components.

To attach a hose to a fitting, simply shove it in with firm pressure, supporting the block or device with your other hand. Test each hose with a light pull to make sure it's seated. To remove a hose, drain the system and then press down on the fitting's collar as you tug on the tube.

We initially had a tough time getting hoses on the blue, plastic Y-adapter that rejoins the water flow from the CPU block's two outlets (remember, the middle coupling is the CPU's inlet). Here's the trick that worked for us: Dip the hose tips in hot water for a minute. They'll slide right on. Grab the wet hoses with a napkin to keep from scalding yourself.



We've seen better core clocking from a Radeon 9800 Pro with stock cooling. Remember, though, watercooling can only help your chips reach their potential. It's the luck of the draw.



Here's the mounting hardware for the video card's waterblock. This is a much better arrangement than the nylon ties provided for the northbridge block.

We left the radiator hoses till last. We wanted to be able to set the radiator assembly as far from the back of the case as we liked. Asetek graciously provided more hose than we needed. We ran the radiator tubes and its fan's power cable through an unused expansion port slot.

Power. Electricity for the water pump comes through an AC pass-through adapter. It fits between the power supply and its wall cable. We attached it, but not the power supply's AC cable just yet. The pass-through adapter cable enters the case through an expansion slot bracket, which you'll have to feed through the slot before you screw it in to place.

Connect the small end of the adapter cable to the matching connector on the back of the pump's control box. On the other end of the box, attach a floppy-style power lead from the power supply, plus the radiator fan's power cable. There's a jumper on the control box to set the radiator fan to 12V or 7V. We moved it to 12V so the fan's higher (and louder) speed would handle any overclock we tried.

Test run. Now we could try out the watercooling system without powering up the motherboard, CPU, video card, and the rest of the PC. If we had started the whole system with nothing but protective tape between the waterblocks and major chips, we would have cooked something.

To do a test run, we needed to hack the power supply's 20-pin main harness. You do not want this harness connected to the motherboard at this time. We made sure the p/s was still unplugged from the wall, but that the water pump's power adapter was connected to the power supply.

There was a short wire with green insulation included with the kit. We pulled off the precut insulation on each end. Next, we bent the wire and shoved it securely into the 20-pin harness' pins 13 (black wire) and 14 (green wire). If your harness connector isn't labeled, as ours wasn't, turn the connector to face you with the retaining latch on top. Pins 13 and 14 are on the top row, third and fourth pin from the left. Double-check that you're shorting the right pins and then set the harness aside.

Next, we mixed about a liter of distilled water with the algae inhibitor included with the kit. We used a clean Powerade bottle—which holds almost a liter—to make pouring easier. We attached the power supply's AC cable and plugged it into a surge protector, and our pump started to run. We popped the cap off the reservoir and carefully added a little water. At the first sign of a leak, we immediately pulled the power supply's AC cable out of the pump's pass-through adapter to kill current to the system.

Yowzah! Our meticulously constructed water park started to leak like a senator on an intelligence committee. One leak was in the VGA block, and the other was in a reservoir coupling. We mopped up all the water and then retrimmed the ends of the leaking hoses. Frustrated, we triple-checked that our hoses were shoved in all the way and wouldn't come back out when we tugged on them with moderate pressure.

This time we left everything off and jiggled the trouble areas while we added some water. No leaks showed, so we tried powering on. After a few minutes, one of the reservoir fittings leaked again, but that was nothing compared to the gushers from the northbridge block. We took care

System Notes

We ran PCMark04 (version 1.2.0, with Windows Media Player 9) and 3DMark03 (build 340, with DirectX 9.0) at default settings, plus Doom3's Timedemo1 at 1,024 x 768 at medium quality with no AA. We overclocked the CPU and RAM in the ASUS BIOS with automatic voltage settings. The ATI video card drivers were Catalyst 4.7; we overclocked the card with ATITool 0.0.20.

	Stock	Overclocked
CPU (GHz)	2.4	3.424 (43%)
RAM (MHz)	400	570 (43%)
Video Core (MHz)	378	415 (10%)
Video RAM (MHz)	338	380 (12%)
Temperature (CPU; Celsius)	26 idle; 27 during PCMark	26 idle; 30 during PCMark
Temperature (Motherboard; Celsius)	33 idle; 33 during PCMark	33 idle; 35 during PCMark
PCMark04 System	3743	5101 (36%)
CPU	3458	5007 (45%)
Memory	3874	4870 (26%)
Graphics	4088	4569 (12%)
Hard Drives	4160	4122 (-1%)
3DMark03	5607	6394 (14%)
Doom 3 (fps)	36.1	43.3 (20%)

Overclocking

We chose to interpret "versatility" for this watercooled system as the number of components with enhanced overclocking potential. To hit our budget, we cut out a few amenities, such as DVD burning, in order to gratify the majority of overclockers—namely, gamers—with a respectable graphics card.

Pros

- Watercooled CPU, video card, and motherboard northbridge
- OCZ Gold Edition PC4400 DDR 2x256MB (2.5-4-4-8)
- Aluminum Lian-Li PC-61 case
- Sapphire Radeon 9800 Pro 128MB
- Copper heatsinks on DIMMs and video RAM
- Pentium 4C 2.4GHz
- Four case fans plus power supply and radiator fans

Cons

- Only 80GB of storage space
- No DVD±RW

of those rough hose ends with a fresh razor blade in our box cutter tool. This made much smoother edges. However, fixing these leaks revealed yet another, this time on the CPU block. After we dressed the rest of the hose edges, we finally had a leak-free test.

Unfortunately, our trimming left one of the CPU outlet hoses with a slight bend. It didn't completely crimp, though, and the other outlet from the CPU block would pick up the slack. We decided to quit while we were ahead. Quick-disconnect fittings like the CT-Joints in our kit are convenient, but every hose end must be absolutely flat for them to seal.

We let the pump run until it displaced most of the air bubbles visible in the hoses. We kept the reservoir about two-thirds full. The inline pump made a racket caused by cavitation until it purged the air from the system. We helped with gentle maneuvering of the hoses, radiator, and reservoir. Note that when there are big bubbles in the system, the water goes nowhere. This explains why the heater in your old Mercury was so hard to keep operational. Once the pump forces the bubbles out, though, the water will start to flow with a whoosh, and everything gets much quieter. We replaced the reservoir cap and kept an eye on the system for a couple of hours. Finally, we removed the video card from its slot, still damp from the CPU and northbridge leaks, and let everything dry for several hours.

Light 'em up. It was the moment of truth. Time to attach the waterblocks properly. Refer to the three waterblock sections above for instructions on proper mounting, sans protective tape but with a thin layer of thermal grease. We started with the northbridge block, as we guessed rightly that its nylon ties would make it the hardest to attach.

One more dry run to verify that we hadn't created any new leaks while mounting the blocks, and we were ready to start the PC for real. We pulled the green shunt wire from the power harness and then connected the harness to the motherboard. We kept the wire in a safe place, as we knew we'd need it to help us purge the air from the water-cooling system after every flush and refill.

We installed the rest of the PC parts, including the heatsinks for the video card's RAM. Unfortunately, the ThermalTake copper RAM heatsinks we bought for our original Radeon 9200's rectangular memory chips didn't fit the squarish RAM on the much faster 9800 Pro. We could have returned the sinks for the right size or headed toward the garage to slice the sinks with a band saw. A looming deadline settled the issue: We attached the sinks as is.

Parts List

Component	Model	Price
Case	Lian-Li PC-61 Black	$85
Motherboard	Asus P4C800-E Deluxe *	$172
Processor	2.4GHz Pentium 4 Model C 800MHz FSB 512KB L2	$160
Memory	2x256MB OCZ PC4400 Gold Edition CAS 2.5 4-4-8	$189
Hard Drives	80GB Maxtor 6Y080M0 SATA 7,200rpm 8MB cache	$83
Video Card	Sapphire Radeon 9800 Pro 128MB *	$185
Optical Drive	AOpen 52X/32X/52X Chameleon CD-RW	$26
Monitor	Samsung SyncMaster 753DF (17-inch, 1280 x 1024, 0.20mm)	$119
Floppy Drive	Sony MPF920ZCU1 3.5-in 2HD Floppy Drive Internal	$4.88
Power Supply	Antec True430 430W	$59
Mouse	Logitech Optical Wheel 3-button Mouse	$8.59
Keyboard	Belkin ErgoBoard USB / PS/2	$16
Operating System	Windows XP Home Full OEM Version	$90
Miscellaneous	Distilled Water	$2
	Asetek WaterChill Cooling Kit CPU/Chipset/VGA	$279
	2x ThermalTake A1414 Copper Memory Cooling Kits *	$12
	ThermalTake A1978 Copper RAMsink Kit	$9.50
Total		**$1,499.97**

** Equipment previously purchased*

Upon startup, we entered the BIOS Setup. All we had to change at this stage was the boot priority to diskette, CD-RW, and then hard drive. Later, we connected the rear fan to the CPU FAN header to avoid seeing an error message on every startup.

Finally, we installed Windows XP. Unlike with the AMD-compatible motherboards we've used, we didn't have to press F6 early in Windows Setup and then supply a SATA driver diskette. The Intel ICH5 southbridge transparently supported the SATA hard drive.

Testing

We benchmarked this PC stock and then overclocked it using ATITool 0.0.20 and the relevant settings in the BIOS. This netted us an extra 1GHz of CPU speed (43%) before apps started to hang, for a 36% overall gain in PCMark04, 14% in 3DMark03, and 20% in Doom 3 frame rates.

This particular R350-core Radeon 9800 Pro was a disappointment in the o/c department. We've had samples that have reached a 430MHz core speed (up from 378MHz) with the stock heatsink, yet this card generated artifacts at a mere 419MHz with a waterblock solidly attached. It just goes to show you that overclocking is somewhat of a crapshoot.

Final Remarks

This system cooled itself better with both side panels on. It's worth it to trim your water hoses to help everything fit inside the case. For even better airflow, we'd recommend rounded data cables for the drives.

With the radiator fan set to 12V, our watercooled PC was no quieter than a typical fan-cooled gaming rig. And we tried to ignore that a 3.4GHz P4 cost a little less than our 2.4C and Asetek kit combined. Still, we'll be able to reuse the watercooling system on future processors, video cards, and motherboards, with minor adjustments. Now that's cool. RS

by Marty Sems

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